Concrete

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An Analysis of Certain Factors Affecting Segregation in Concrete

Causes of Variations in Strengths of Concrete—Methods of Controlling These Factors—Accurate Proportioning —Separation of Materials in Handling Concrete—Workability—Effect of Gradation of Aggregates on Strength of Concrete — Effect of Segregation on Strength of Concrete

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AN analysis of test cores taken from hundreds of miles of concrete pavement indicate that normal field concrete varies considerably in compressive strength. Drilled cores have varied from sixty-five to over two hundred per cent of the standard test specimens cast from the same concrete at the time of placing. The cast specimen is therefore, at best, a questionable means of determining quality in field concrete and is valueless in detecting its uniformity. The latter quality is of greatest importance.

Uniformity in concrete means economy. Concrete structures are more susceptible to attack or failure at their weakest points regardless of the average or maximum strength. The practical effect of non-uniformity in concrete when under uniform stress, is analogous to uniform concrete subjected to eccentric loading. The structure is protected against the latter by the use of greater amounts of steel reinforcement or more concrete where needed. The weaker places, caused by variation in the concrete itself, cannot be compensated for in this manner because their location is unknown.

Correction may be made by one of two methods; either by the usual costly method of over-designing to care for such minimum or lower strengths, or by adopting an average strength having a lower factor of safety, and taking steps to secure uniformity throughout the entire structure.

Causes of Variations

The normal variation in materials from average sources is by no means as great as the variation encountered in the finished concrete. It is obvious, therefore, that we must look beyond the materials for the most important cause of such non-uniformity.

In present practice, the matter resolves itself into means to control the various factors which cause the extremes in variation from the average. The reasons for such variations are fairly well recognized, as shown by demands for rigid inspection, but the knowledge of the extent to which each variable affects the strength of the whole, is by no means general.

With concrete materials accurately proportioned, the greatest variation is caused by the separation of the constituent materials while the freshly mixed concrete is being handled. The result is segregation in the hardened mass. Each material in itself composing a concrete mixture has an effect on the strength. The relation of one to another offers additional complications. An excess or deficit of a given material in any part of the mass is an indication of segregation and causes a variation in strength.

Segregation Tests

Considering two stresses, compression and impact, to be fairly representative of those to which a pavement is subjected, the effect of segregation is shown in Figures 1 to 7.* Segregation, as shown by these figures, is considered

Figure 1

INDICATION OF NON-UNIFORMITY OF FIELD CONCRETE

Results of Tests for Compressive Strength on Cores Drilled every 500 ft. from Typical Pavement. Age at Test – 13 to 18 Months

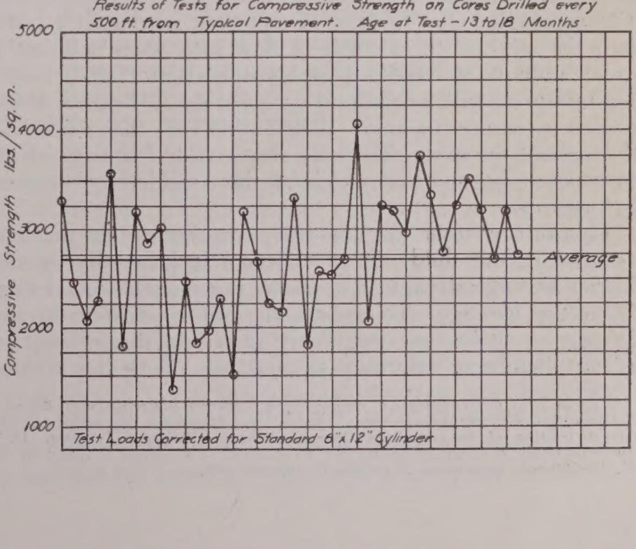


TABLE ONE

Compressive Tests of Concrete—Series 23-106

Gradation Number	7 Days Lb. sq. in.	7 Days Rel.	28 Days Lb. sq in.	28 Days Rel.	3 Months Lb. sq. in.	3 Months Rel.	1 Year Lb. sq. in.	1 Year Rel.
1	1470	100	2058	140	2153	146	2416	164
2	1623	100	2242	138	2540	157	2753	170
4	1610	100	2201	137	2611	162	2940	183
3	1808	100	2467	136	2568	142	3017	167
7	1918	100	2750	143	3009	157	3076	160
6	1732	100	2583	149	2859	165	3291	190
5	1789	100	2630	147	2871	160	3314	185
8	1764	100	2462	140	3032	172	3318	188
20	1776	100	2678	151	3197	180	3357	189
14	1832	100	2842	155	3216	176	3453	188
16	1827	100	2520	138	3104	170	3470	190
12	1788	100	2746	154	3192	179	3515	197
13	2026	100	2922	144	3344	165	3684	182
9	2118	100	3031	143	3340	158	3687	174
11	1967	100	2851	145	3102	158	3704	188
15	1978	100	2839	144	3326	168	3735	189
21	1858	100	2759	148	3099	167	3748	202
10	1994	100	2887	145	3304	166	3766	189
17	1962	100	2864	146	3237	165	3798	194
18	2050	100	2903	142	3356	164	3840	187
19	2043	100	2888	141	3244	159	3914	192

KEY TO GRADATIONS IN TABLE ONE

Table of Gradations of Coarse Aggregate—Series 23-106
Ratio Fine to Coarse Aggregate = 1:2 (by volume) 25 per cent Cement
(by Dry Volume)

Gradation No.	⅜-¾ in.	¾-1½-in.	1½-2¼ in.	Total
1	00	00	100	100
2	00	20	80	100
3	20	00	80	100
4	00	40	60	100
5	20	20	60	100
6	40	00	60	100
7	00	60	40	100
8	20	40	40	100
9	40	20	40	100
10	60	00	40	100
11	00	80	20	100
12	20	60	20	100
13	40	40	20	100
14	60	20	20	100
15	80	00	20	100
16	00	100	00	100
17	20	80	00	100
18	40	60	00	100
19	60	40	00	100
20	80	20	00	100
21	100	00	00	100

in the light of a varied amount of cement, or amount and size of coarse aggregate in a given volume of hardened concrete. The tests represent segregation more as a change in the relative amounts of the various materials present in a unit volume, rather than segregation in the more apparent stages as evinced by honeycombing. It considers the segregation in a concrete which can only be detected by the non-uniformity of the strength tests or possibly by a study of the structure by means of exposed planes.

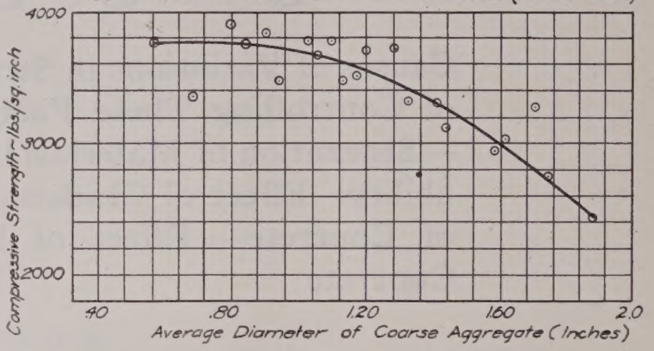
In these tests, the fine aggregate bears a ratio constant to the ingredient under discussion. A blend of several standard brands of portland cement; an average well graded fine aggregate; and a high quality of granite, as coarse aggregate, were used in the tests. The consistency was that normally used for first class concreting operations.

Figure 1 shows typical variation encountered in concrete road construction. The main causes of such variation are: (1) inaccuracy in proportioning the aggregates and (2) separation due to lack of sufficient workability built into the mixture to allow it to flow into place without a great amount of handling or manipulation (harsh working mixtures, with or without excess water). Both of these causes promote unequal distribution of the materials throughout the mass. They are responsible for a variation in concrete beyond that which can be considered economic in practice.

Laboratory tests do not truly represent the product secured in the field. Field concrete is generally of the higher average strength, but shows much greater variation from the average. To approach field conditions in the laboratory, it becomes necessary to eliminate any method of test involving arbitrary proportions. Both the cement and aggregate content vary considerably in different mixtures even though the arbitrary proportions as called for by the specifications may be the same. Testing concrete makes it necessary to picture a given volume of concrete in place. It must contain a definite volumetric amount of each ingredient in relation to a unit of completed mixture of a given consistency. This method requires that the finished volume of concrete, with given amounts of materials, be determined in advance. The greatest advantage is that it eliminates the effect of all variables except the one under investigation. With respect to the volume of concrete, all materials are constant in their amount by displacement when this method is used.

Figure 2

EFFECT OF SIZE OF COARSE AGGREGATE UPON COMPRESSIVE STRENGTH OF CONCRETE (AGE-1 YEAR)



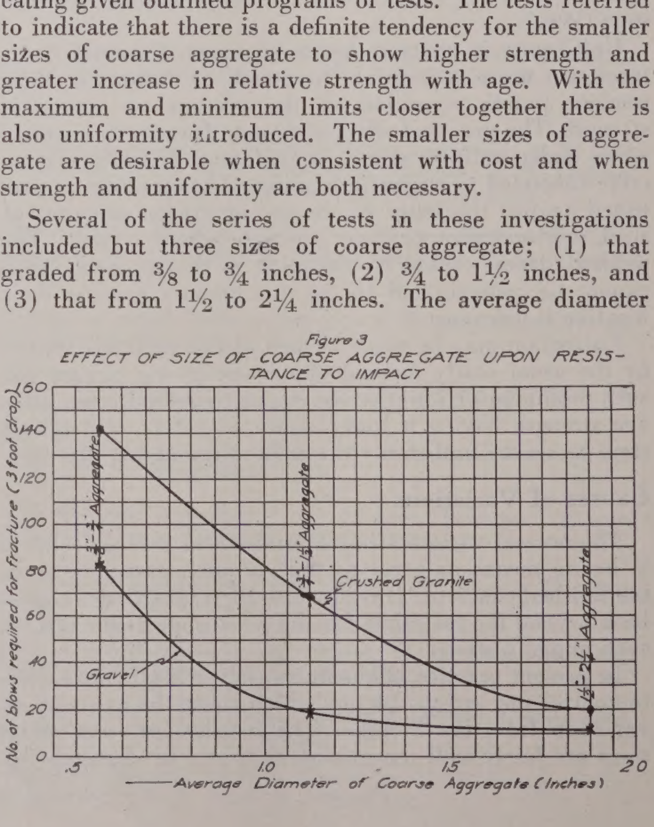
Effect on Compressive Strength

The effect upon the compressive strength of various gradations of coarse aggregate, within the limits generally used for highway construction, is given in Table One. Each result is the average of ten specimens. The results are typical. Variation in such results would be secured by changes in the cement, either in quality or amount, as well as by changes in types of aggregates. Incidentally such changes offer one of the reasons for the failure of different research laboratories to check results when duplicating given outlined programs of tests. The tests referred to indicate that there is a definite tendency for the smaller sizes of coarse aggregate to show higher strength and greater increase in relative strength with age. With the maximum and minimum limits closer together there is also uniformity introduced. The smaller sizes of aggregate are desirable when consistent with cost and when strength and uniformity are both necessary.

Several of the series of tests in these investigations included but three sizes of coarse aggregate; (1) that graded from ⅜ to ¾ inches, (2) ¾ to 1½ inches, and (3) that from 1½ to 2¼ inches. The average diameter

Figure 3

EFFECT OF SIZE OF COARSE AGGREGATE UPON RESISTANCE TO IMPACT



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*Figures 1 to 6 from paper, "Proportioning Concrete Materials with Especial Reference to Highway Construction," by G. W. Hutchinson, presented at the annual meeting of the American Concrete Institute, Chicago, February, 1925. Figure 7 from "A Study of Impact and Its Relation to Pavement Design," by G. W. Hutchinson, *Engineering News Record*, March, 1925.

of each of these sizes is practically twice that of the next smaller and one-half of the next larger. When the aggregate is graded between wider limits, the effect is the same and the strength as well as the resistance to impact appears to be a function of the average diameter of the particles when other factors are constant. (See Figure 2.)

It will be noted that the segregation of coarse aggregate in a normal concrete mixture can be responsible for a variation of over sixty per cent of the minimum strength of the concrete. The data given apply to a mix of approximately 1:1¾:3½ or 1:2:3 proportions. Changes in the cement content, with changes also in the size of the coarse aggregate will have a certain effect on this variation as well as upon the relative increase in strength with age.

In general, the greater the maximum size, or average diameter of the coarse aggregate particles, the weaker the concrete (with the cement, fine aggregate and consistency constant). Such mixtures, containing the larger sizes, are also less susceptible to reaction on strength, when caused by changes in the amount or quality of the other materials used (see Figure 6). The quality of such concrete, containing normal amounts of cement, is too low to allow much reaction to certain factors which lend themselves more favorably to mixtures containing the smaller sizes of coarse aggregate. This is true both with regard to compressive strength and the resistance to impact.

Figure 4
RELATION BETWEEN COMPRESSIVE STRENGTH AND RESISTANCE TO IMPACT OF CONCRETE

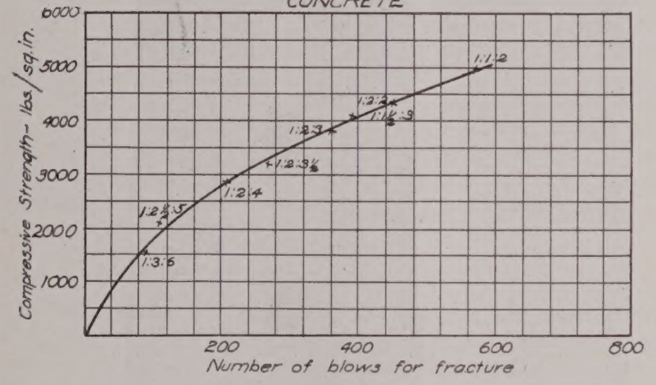
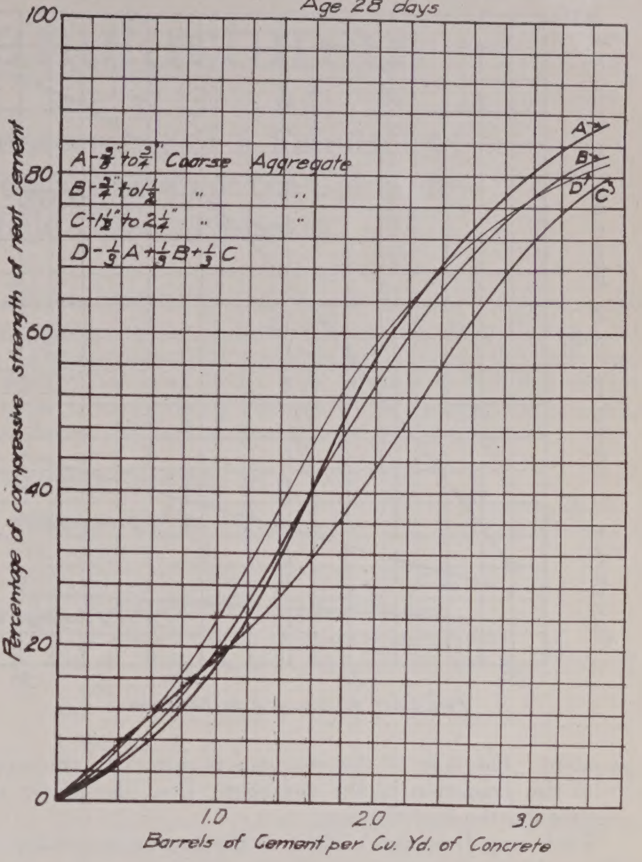


Figure 3 indicates the variation in the resistance to impact of the suspended slab such as might be due to segregation of the coarse aggregate. The resistance to impact is decreased as the size of the aggregate is increased. With a well graded aggregate in normal laboratory concrete, the resistance to impact is proportional to the compressive strength. This relation is shown in Figure 4.

Effect of Segregation

Segregation in concrete carries with it an unequal distribution of cement. The typical effect of cement on the compressive strength of concrete, with various sizes of coarse aggregate, is shown in Figure 5. An indication of the effect of cement on the resistance to impact is given in Figure 6. Consideration of impact on concrete is of great importance in highway construction. Test cores drilled from pavements often show honeycombing at the bottom of the slab. This is due to segregation and lack of workability, as well as the use of large aggregate and consistencies either too wet or too dry for the purpose. Segregation of this kind is not only reflected by decreased strength and uniformity of the concrete, but also by decreased effective slab thickness. The typical effect of the thickness of unsupported (resting on three point bearing only) slabs on the resistance to impact is indicated by Figure 7.

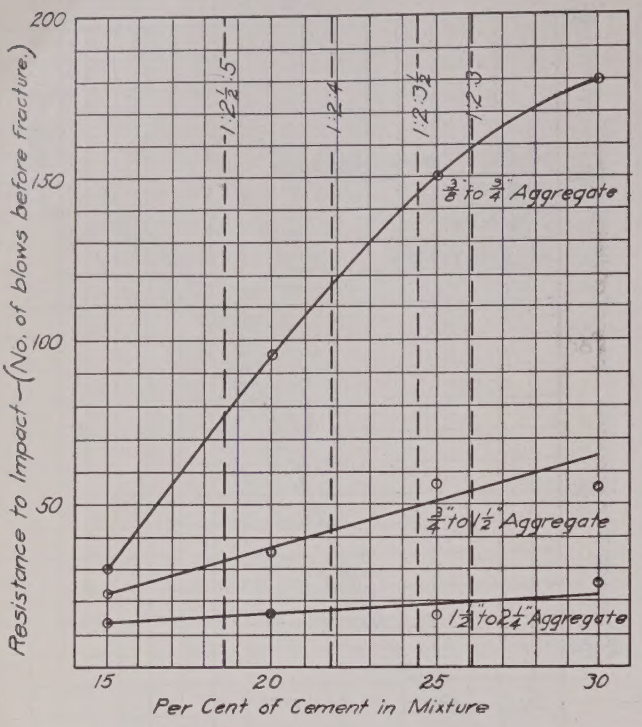
Figure 5
TYPICAL EFFECT OF CEMENT CONTENT ON RESISTANCE TO COMPRESSION
Concrete made with various sizes of coarse aggregate.
Age 28 days



The data included in this paper indicate several reasons for the variation in strength as found in field concrete. With accurate proportioning of the aggregate and cement, all other conditions encountered during the handling of the mixture can be improved by increasing the workability and preventing segregation. It is important to recognize the distinction between consistency and workability. Consistency is dependent to a great extent upon the water content and is measured by the slump or flow. Workability is governed by the physical properties of the solid ingredients and refers to the ease with which the mixture can be satisfactorily handled and placed without segregation. Excess water is sometimes used to promote workability but it does not serve this purpose in a true sense. From the standpoint of the finished work, the use of excess water should be carefully avoided as it not only reduces the average strength, but is the primary cause of segregation and non-uniformity.

The principle of concrete design is economy. Aggregate as large as one man stone is combined with low cement content in certain classes of concrete where weight and mass, except low cost, are the only requirements. In highway construction the maximum size of the aggregate is generally but about 2¼ inches and the cement content is increased accordingly. Both are due to the requirement for higher quality. In the yet higher type, such as reinforced concrete, the size of the aggregate is still further reduced in order that the finished structure will be more suitable for the designed purpose. In work of the highest type it is necessary to eliminate the so-called coarse aggregate and use the finer aggregate with a still greater cement

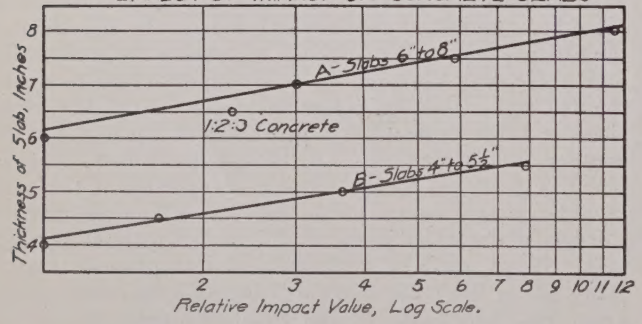
Figure 6
TYPICAL EFFECT OF CEMENT ON RESISTANCE TO IMPACT
Concrete made with various sizes of coarse aggregate.



content. The cost of the concrete is generally consistent with the gradation of the aggregate, i. e., the larger the aggregate, the less the cost.

Each step from the highest to the lowest in quality, or from the sand cement mixture to that containing coarse aggregate graded up to one man stone or plums, carries with it an increasing necessity to provide workability for economic reasons. For this purpose, certain approved admixtures are desirable. The combination of fine aggregate and cement should be used as a basis in designing a mixture, and the addition of coarse aggregate, both with respect to amount and to size, should be determined by a comparison of cost and the possibilities of placing the concrete properly. The latter can be generally accomplished most economically by the use of admixtures.

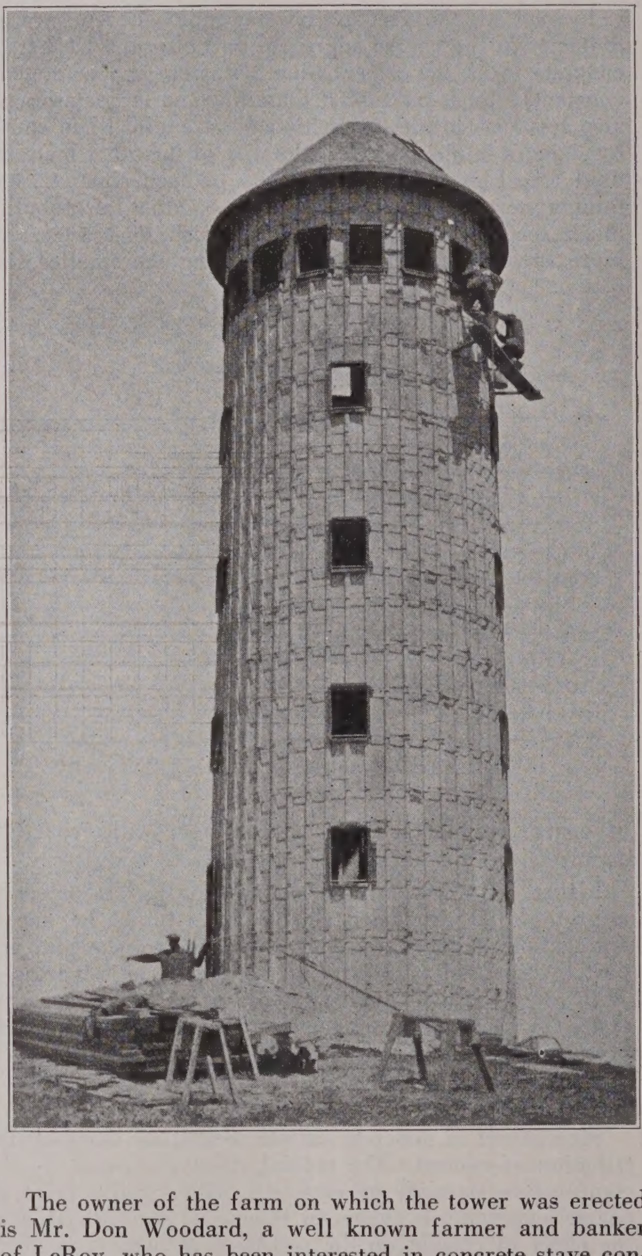
Figure 7
EFFECT OF IMPACT ON CONCRETE SLABS



How concrete masonry units resisted fire in a large church will be told in next month's leading article. This will be particularly timely, as Fire Prevention Week will be observed October third to ninth.

Concrete Stave Structure Is First of Kind

To George N. Priest, general manager of the Ribstone Silo Company of LeRoy, N. Y., belongs the credit for erecting what is perhaps the first lookout station of concrete stave construction. The tower, which stands on the top of a 100 foot hill, which is the highest land in Genesee County, New York, is 60 feet in height and 20 feet in diameter. The Ribstone or "S T P" type of stave was used, each unit being 30 inches long, 14 inches wide and 2 inches thick.



The owner of the farm on which the tower was erected is Mr. Don Woodard, a well known farmer and banker of LeRoy, who has been interested in concrete stave construction for a number of years. Mr. Woodard conceived the idea of putting up a concrete tower on the crest of his hill which can be seen for many miles in all directions. He wanted a structure which would ornament the landscape, serve as a lighthouse, watch tower for fires, weather observatory and also have recreation facilities.

The building is fully equipped with hot water heat, plumbing, lighting and other modern conveniences. Erection was completed in June, 1926.

Building Code Enforcement Helps Products Manufacturers

How the Rigid, Impartial Enforcement of a Fair Building Code Lead to a Remarkable Expansion of the Concrete Products Business in Springfield, Massachusetts

IN the city of Springfield, Massachusetts, the municipal building department, under the direction of its veteran commissioner, Fred W. Lumis, assisted by Leigh Morgan, inspector in charge of tests, vouches for all masonry material of every kind going into the walls of local buildings. In Springfield, not only do the codes provide explicitly what the minimum quality of the materials shall be, but at the suggestion of Commissioner Lumis the city council provided his department with the necessary apparatus to test building units such as brick, tile and block in the city's own laboratory.

As a result, Commissioner Lumis and his assistants have been performing an unusual service to the building public by sampling and testing such material from almost every individual job—even down to small residences. Further tests of the materials are made at intervals on piers or wall sections, providing data valuable to the manufacturer of building material as well as to the building department and the designers of structures, whose business it is to look after the safety of buildings. Few building departments, up to the present, have gone into the matter of wall materials so thoroughly, the great majority being handicapped for even the moderate funds required for a simple testing program.

Code Impartially Enforced

The methods of procedure employed by the Springfield building department soon won the support of most of the manufacturers of wall materials, being frankly and impartially enforced. The manufacturers of concrete brick, block and concrete building tile in Springfield, including the members of the Connecticut Valley Concrete Products Association, were quick to realize the commercial value of the building department's approval on its products and have been cooperating heartily. According to F. E. Caldwell, general manager of the Springfield Sand and Tile Company, the result has been a general improvement in demand for concrete building materials noticeable almost every month. Much of the test data is used effectively by salesmen throughout the community in proving to customers that they are getting a big money's worth in city tested material at ordinary prices. The progressive manufacturers are gladly paying the city's nominal charge for inspection and testing service, finding it quite reasonable when considered in the light of advertising and as a protection against the possible competition of irresponsible makers of materials, who might otherwise let the quality of their wares lag, in order to cut the selling price.

Incidentally, the rigid testing of concrete materials has shown them up to good advantage in comparison with prevailing grades of competing wall units. While the building department has been absolutely impartial, devoting itself primarily to protecting the building public, concrete products manufacturers who have been exceeding requirements have made capital of the situation as they had a right to. It is safe to say that prejudice against poor quality rock faced blocks prevailing in Springfield not so long ago has practically disappeared, and for many purposes concrete masonry is rapidly becoming the preferred type.

The accompanying test data will indicate the high character of the work being done by the city building department in ascertaining the quality of concrete units manufactured and sold in Springfield and vicinity:

Research Test No. 25

Concrete tile, manufactured by the Springfield Sand & Tile Company.

Size, 11⅝x7⅝x5 inches. Area, 88.6 sq. in.
Age of specimens when tested, 84 days.
Compression tests on individual specimens:
No. 1. Total load at failure, 103,720 lb.=1170 lb. per sq. in.
No. 2. Total load at failure, 101,060 lb.=1140 lb. per sq. in.
No. 3. Total load at failure, 96,390 lb.=1088 lb. per sq. in.
Average total load at failure, 100,390 lb.; 1133 lb. per sq. in.

Compression test on pier (No. 2) made of above tile, laid up at age of 60 days, tested 30 days later:

Pier height, 36 inches (7 courses).
Size, 11⅝x7⅝ inches. Area, 88.6 sq. in.
Total load at failure, 90,600 pounds.
Load per square inch at failure, 1022 pounds.

Research Test No. 30

Concrete tile, manufactured by the Springfield Sand & Tile Company.

Size, 11⅝x11⅝x5 inches. Area, 135 sq. in.
Age of specimens when tested, 45 days.
Compression tests on individual specimens:
No. 5. Total load at failure, 142,880=1058 lb. per sq. in.
No. 4. Total load at failure, 197,790=1465 lb. per sq. in.
No. 6. Total load at failure, 150,120=1112 lb. per sq. in.
Total load average at failure, 163,596; 1211 lb. per sq. in.

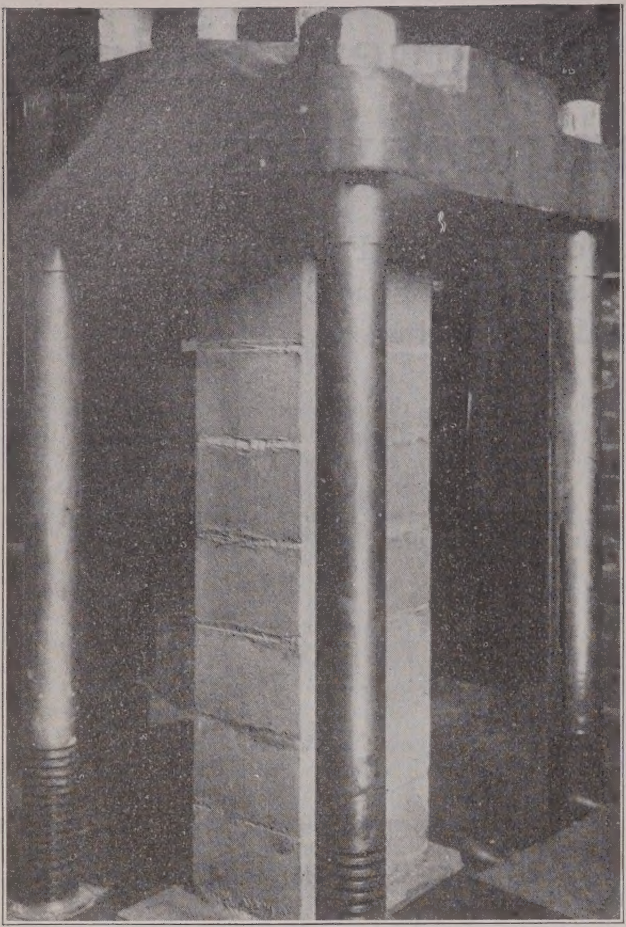
Compression test on pier (No. 4) made of above tile, laid up at age of 45 days, tested 30 days later:

Pier height, 36 inches (7 courses).
Size, 11⅝x11⅝ inches. Area, 135 sq. in.
Total load at failure, 147,040 pounds.
Load per square inch at failure, 1089 pounds.

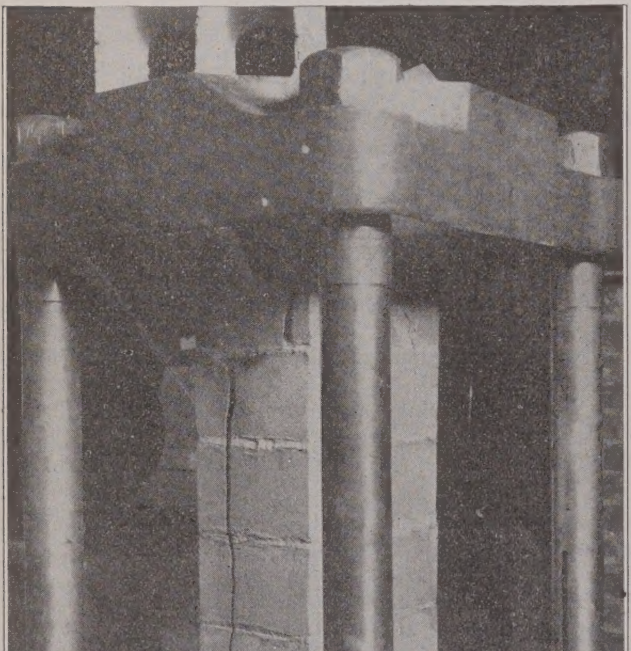
Research Test No. 31

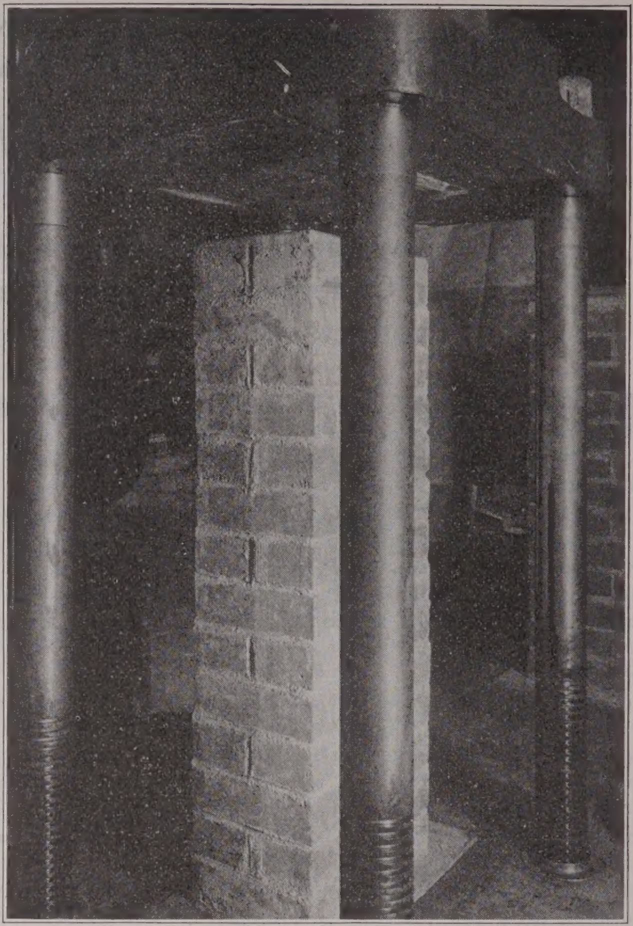
Concrete tile, manufactured by the Springfield Sand & Tile Company.

Size, 11⅝x5⅝x5 inches. Area, 65.4 sq. in.
Age of specimens when tested, 58 days.
Compression tests on individual specimens:

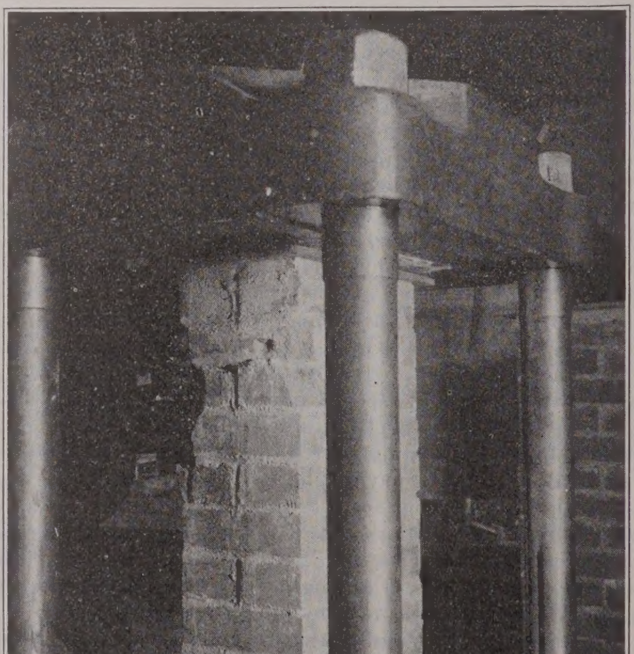


Research test No. 25, Springfield Building Department Laboratory, before and after testing concrete tile piers to destruction with a compressive load of 100,390 pounds, or 1133 pounds per square inch of gross sectional area





Research test No. 29, on concrete brick, indicated a product of excellent quality with a pier load of 1373 pounds per square inch at failure



No. 1. Total load at failure, 105,250=1609 lb. per sq. in.

No. 2. Total load at failure, 98,340=1352 lb. per sq. in.

No. 3. Total load at failure, 84,540=1292 lb. per sq. in.

No. 4. Total load at failure, 73,100=1117 lb. per sq. in.

No. 5. Total load at failure, 70,930=1084 lb. per sq. in.

No. 6. Total load at failure, 60,460=924 lb. per sq. in.

Average total load at failure, 82,101=1229 lb. per sq. in.

Compression test on pier (No. 5) made of above tile, laid up at age of 27 days, tested 30 days later:

Pier height, 36 inches (7 courses).

Size 11⅝x5⅝ inches. Area, 65.4 sq. in.

Total load at failure, 59,250 pounds.

Load per square inch at failure, 906 pounds.

Research Test No. 29

Concrete brick manufactured by P. Tebaldi, Indian Orchard, Mass.

Size, 8x3⅜x2⅛ inches. Area, 30 sq. in.

Age of specimens when tested, 52 days.

Compression tests of individual specimens:

No. 1. Total load at failure, 59,090=1969 lb. per sq. in.

No. 2. Total load at failure, 60,150=2005 lb. per sq. in.

No. 3. Total load at failure, 64,050=2135 lb. per sq. in.

Average total load at failure, 61,096=2036 lb. per sq. in.

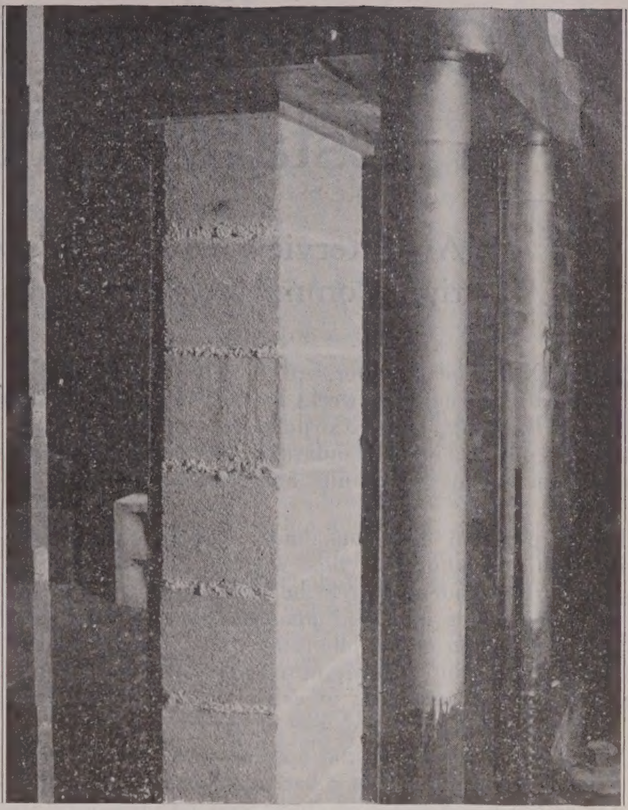
Compression test on pier (No. 3) made of above brick, laid up at age of 21 days, tested 30 days later:
Pier height, 36⅜ inches (14 courses).
Size, 8x12⅜ inches. Area, 99 sq. in.
Total load at failure, 136,000 pounds.
Load per square inch at failure, 1373 pounds.

High Strength in Walls

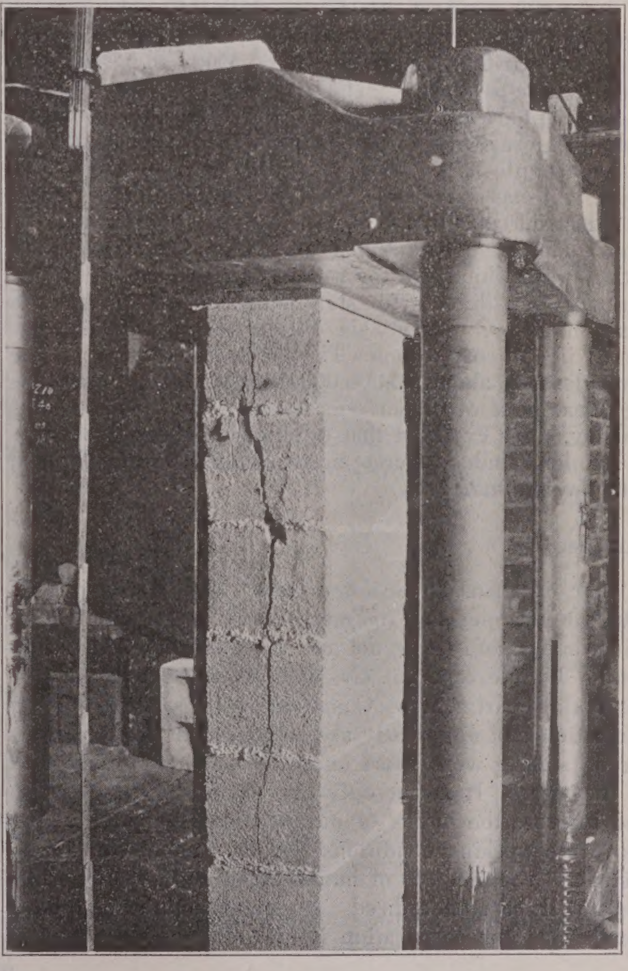
An examination of results of the above tests will show a prominent characteristic of concrete masonry well maintained—high compressive strength of the laid up masonry as compared with that of individual units. In research test No. 25, for example, the average compressive strength of the three individual units at failure was 1133 pounds per square inch on the gross cross-section. The compressive load required to test to failure pier No. 2, built of these units was 1089 pounds per square inch on the gross section, the ratio of the latter to the former being approximately 90 per cent.

Similarly, in research test No. 30, the average compressive strength of the three units selected was 1211 pounds, and the maximum test load carried by pier No. 4, constructed of units of the same lot was 1089 pounds, with a ratio of 90 per cent. While in research test No. 31, the ratio of the pier load to that of the average of six selected units was only 74 per cent, this figure is still far above those ordinarily obtained in comparable tests on clay masonry.

The ratio of the pier strength to that of individual brick in research test No. 29 was 68 per cent, again higher than is usually obtained with clay brick under similar circumstances.



Research test No. 31, on a pier made by 6 by 12 inch tile (actual size 5-5/8 by 11-5/8 inches) showed a performance far in excess of actual requirements



Cinder Block Manufacturers Establish Headquarters

An Interview with LeRoy Goodwin, Chairman, Executive Committee, National Building Units Corporation

PERMANENT headquarters will be established in Philadelphia in the next few weeks by the recently organized National Building Units Corporation, an organization whose purpose it is to standardize the manufacture of cinder concrete masonry units and broaden the field of their uses.

The corporation has plans under way to establish in Philadelphia a laboratory that will be used for testing and analyzing cinder concrete building units and the aggregates that enter into their manufacture. Not the least important function of the laboratory, according to LeRoy Goodwin, chairman of the corporation's executive committee, will be the conducting of experiments that will lead to increasing the merits and uses of cinder concrete.

Mr. Goodwin expressed the opinion to a representative of CONCRETE that the surface had scarcely been scratched so far as the possibilities of cinder concrete masonry are concerned. He intimated that there were possibilities in the surface textural treatment of such units that may prove to be a revelation in architecture.

As chairman of the executive committee, Mr. Goodwin is the active head of the National Building Units Corporation. Other officers are Charles L. Pierce, secretary; Horace P. Griffith, treasurer; G. H. Muth and Francis J. Straub, vice-presidents. The consolidation was brought about by Charles R. Flint, acting for Flint and Company, industrial organizers, and George M. Benbow, acting for Rufus Whaples and Company, Philadelphia bankers. Mr. Flint, who has participated actively in more than a score of industrial consolidations, expressed the opinion that the cinder concrete corporation is one of the soundest organizations with which he ever was associated, and one which has great possibilities for stabilizing and standardizing a basic industry. Seventy-six Straub licenses are represented in the corporation. Their combined output is the equivalent of about 50,000,000 blocks, which represents the great bulk of cinder concrete units produced in this country. It is expected that eventually all manufacturers of standard cinder concrete masonry will become affiliated with the national body.

Purpose

"Our organization is not a trust," Mr. Goodwin said. "We are not operating in restraint of trade or eliminating fair competition. It is not necessary for me to go into details here except to say that representatives of the national Department of Commerce have studied our organization and apparently are convinced that our reasons for organizing were based on good business motives, and so they were. It is not only our purpose to standardize and increase the merits of our products, but also to improve the working conditions and the methods of manufacture. Even methods of bookkeeping and office management will be standardized. No manufacturer can be a member of our corporation if his products do not meet with the specifications of the strictest building codes. The right has been reserved to revoke the license of any manufacturer whose product at any time fails to meet with our standards."

Aside from continuing the local advertising now being placed by its members, the corporation will conduct a national advertising campaign.

New Equipment

Mr. Goodwin arranged for the writer a demonstration of what he described as the "last word" in block-making machinery, which is now operating in his Camden, N. J., plant. Intimate details of the description of this machine are not ready for publication, but it is said to have a maximum capacity of 480 blocks an hour and an average capacity of 3,000 blocks a day. Patent rights are now being obtained and arrangements are being made for the manufacture of this machine. It will not be placed on the open market but will be operated exclusively in the plants of the corporation, according to Mr. Goodwin. Most of the parts for this machine were made by the Baldwin Locomotive Works and the New York Shipbuilding Corporation and were assembled at Mr. Goodwin's plant. The machine is said to be almost indestructible. In the words of the representative of a machinery supply house, "It's far too strong."

"Cincrete" Trade Mark in Dispute

Washington, D.C.—The right to register "Cincrete" as a trademark is in process of adjudication in the Patent Office. The examiner held in the case of Crozier Straub, Inc., of New York City, against Cincrete, Inc., of Clarksburg, W. Va., that the former is barred from registering the term as a trademark for bricks, blocks, tile and other building units because of the incorporation of Cincrete, Inc., prior to the filing of the Crozier-Straub application, although the incorporation was subsequent to the date of use claimed by Crozier-Straub. The question was raised whether Cincrete, Inc., also was not barred from registration because of the incorporation of Cumberland Cincrete Company and Cincrete Products Company.

First Assistant Commissioner Kinnan subsequently has ruled that under the circumstances of the case the interferences should not be dissolved, but that the parties should be allowed to present testimony since the questions as to their rights to registration in view of the alleged dates of use, the dates of incorporation of the various companies and the dates on which the parties filed their applications could be better determined in an interference proceeding than by an ex parte consideration of the appellee's case after dissolution of the interference.

Water-Ratio on Grain Elevator Job

How the C. M. & St. P. Railway Is Using Abrams Theory with Ordinary Equipment to Obtain Good and Uniform Concrete on Grain Tank Job in Milwaukee

JUST across the canal from the Cincrete plant in Milwaukee, the Chicago, Milwaukee and St. Paul Railway has just replaced an old frame grain elevator that was destroyed by fire. The new structure, of reinforced concrete, joins onto an older structure of concrete tanks that survived the flames which wrecked the still older bins. Concrete was chosen for its permanence and its ability to resist fire. The strength of this concrete was controlled by the application of the Abrams Theory, since by that means the most reliable control is possible with the least trouble.

In controlling the concrete on the work the engineer determined the fineness modulus and water content of the aggregate, and the water-cement ratio required for the desired strength, and then computed the proportions required to give a mix of the desired strength, workability and economy. At the beginning of this job, in mixing the concrete to line the foundation pits, the mix was originally set at 5 sacks of cement, 15 cubic feet of sand, and 20 cubic feet of crushed stone. The required strength (200 lb. per sq. in. or better at 28 days) called for a water-cement ratio of 0.89, or a total water content of 33½ gallons to the batch. The slump averaged 4 inches. Deduction was made for the amount of water in the aggregate and credit for the absorption of the aggregate. Medusa waterproof cement was used in the pits in order that water should not seep through from the canal alongside the structure.

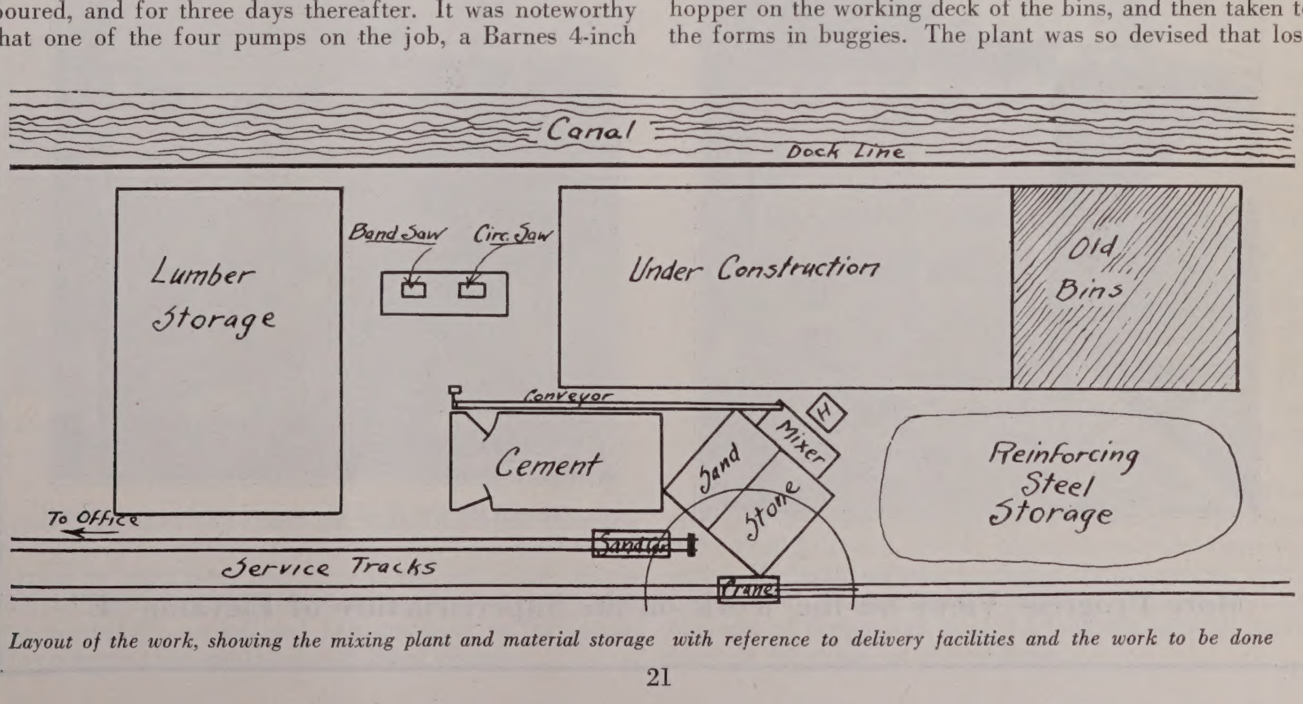
Seven-day compressive strengths and 28-day compressive strengths were taken as a check on the mix. The seven-day strengths were found to average 800 pounds per square inch, and the 28-day strengths were around 2100 pounds.

The pits were formed by driving sheet piling as an outer form, while a regular wall form was built up to form the inner face of the pit walls. Pumps were used to relieve the hydrostatic pressure while the concrete was being poured, and for three days thereafter. It was noteworthy that one of the four pumps on the job, a Barnes 4-inch plunger pump operated by a 4-hp. LeRoi motor, was operating efficiently on a suction lift of approximately 26 feet. All other pumps on the job were of the same make.

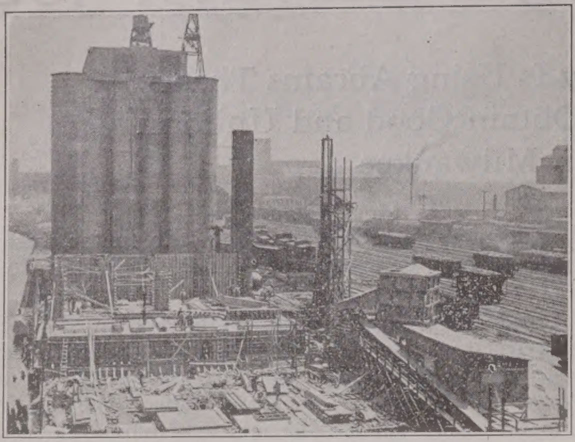
A different mix was used on the bottom slab of the superstructure. Here the cement was standard portland. The coarse aggregate was somewhat different, being a Beloit gravel graded to ¾-inch and under. The sand came from the same source. The mix called for 5½ sacks of cement, 16 cubic feet of sand, and 20 cubic feet of gravel. Since strength requirements dictated a water-cement ratio of 0.89, the water content ranged between 27 and 30 gallons per batch, depending upon the water content of the aggregates and the absorption thereof. With this mix the slump was found to range from 6 to 7 inches. This concrete was found to be quite workable and hardened with gratifying speed. The seven-day strengths were found to reach 700 pounds per square inch, while the 28-day strengths averaged 2275 pounds per square inch.

The Superstructure

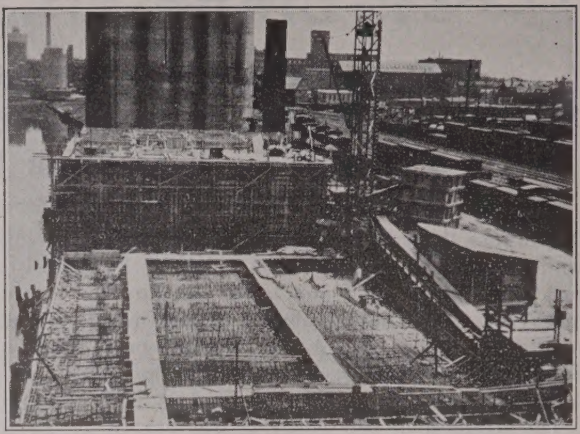
After the slab was poured, the basement and first floor were placed with the use of stationary forms, after which the bins were run up with the use of wooden sliding forms. These forms were of the type devised by the contracting firm and were equipped with jacks also devised by the firm. The forms were jacked up continuously as the work progressed, a turn at a time on each one of the jacks in order that the working platform would remain level and the cylindrical walls plumb. The work progressed continuously in two ten-hour shifts, with an hour out between shifts and an hour for midday lunch for each shift. By means of this continuous operation construction joints were avoided. The concrete was supplied to this work by being discharged from the mixer into an elevator bucket, then hoisted to the top of the tower, chuted to a hopper on the working deck of the bins, and then taken to the forms in buggies. The plant was so devised that loss



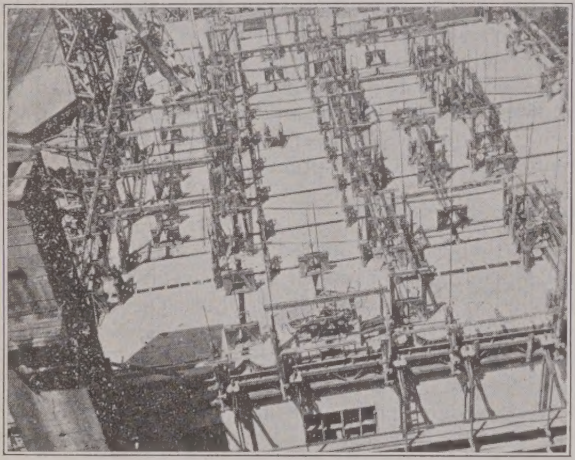
Layout of the work, showing the mixing plant and material storage with reference to delivery facilities and the work to be done



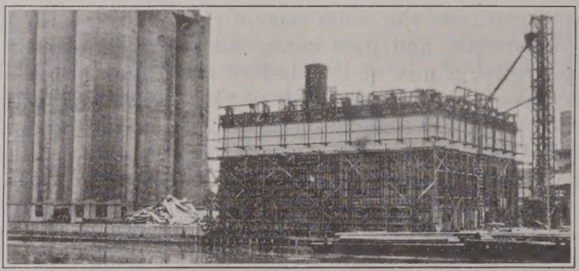
Looking east from old dryer, on June 14



The same view with progress to July 1

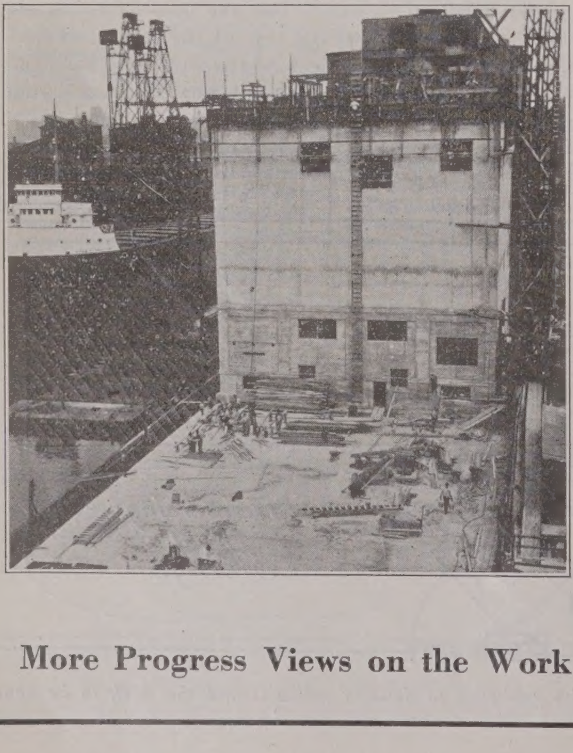


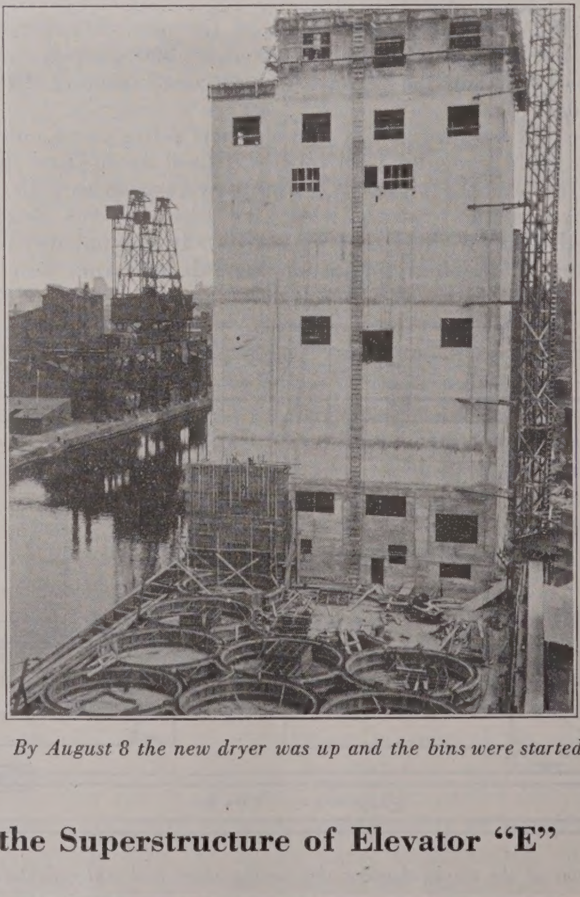
Working deck and movable forms about July 10



The work as it appeared from the canal on July 10

Below: Progress of job to July 18





By August 8 the new dryer was up and the bins were started

More Progress Views on the Work on the Superstructure of Elevator "E"

of revenue from idle equipment was almost negligible when the work was fully under way.

The mix used on this part of the work called for 4½ sacks of cement, 12 cubic feet of sand, and 15 cubic feet of gravel. Later these proportions were changed, without departing from the basic 1:6 mix, by using 10.5 cubic feet of sand and 16.5 cubic feet of gravel. The water content of these batches ranged from 25 to 27 gallons, keeping to the desired water ratio of 0.89. The slump of these mixes was found to be all the way from 6 to 8 inches. Adjustments were made as required.

General view of the mixing plant, with the job at the right, the locomotive crane at the left, the reinforcing steel storage in the foreground, and the form storage in the rear

Job Layout

The layout of the work was in a way quite simple, considering the fact that space was rather limited and the job bordered on one side by a canal and on the other by busy railroad freight yards. The contractors secured the use of several tracks, nearest the work for hauling in the materials, and the material yards and mixing plant were grouped along the nearest track, utilizing all the space between this track and the water.

First, at the end of the roadway that afforded the nearest approach to the job, were located the offices of the owner and the construction firm. Then came the stack of form lumber, on the job side of which was a shed containing a Crescent bandsaw and cutoff saw. These machines were belt driven from a small gasoline motor. The form lumber was carried by hand from this point to the job. Next, alongside the track, was a cement shed, from which the cement was carried by an inclined belt conveyor to the mixer. This conveyor was equipped with Stahl carriers.

Working on the substructure, with the mixing plant at the left and one of the pumps in the foreground. The Cincrete plant may be seen on the other side of the canal

Another view of the work, taken from the track alongside the mixing plant. The completed structure is the old concrete elevator that forms the first unit of the project. It survived the explosion and the fire that destroyed the older wooden structure which stood on the site of the new bins

The centerline of the mixing plant, with the bins alongside the track, was inclined at an angle of about 45 degrees with the centerline of the track, while all other work, was laid out parallel to the track. This placing of the mixing plant, on the corner of the job, was planned for the most convenient handling of the concrete from the mixer to the forms. Two large frame bunkers, loaded from the gondola cars by means of an Orton steam locomotive crane operating on the track, held the aggregates. A clamshell bucket was used in this handling of the materials.

The aggregates discharged into the loading hopper of the mixer through gated spouts in the bins, while the cement was dumped into the mixer by hand. Water was measured in the automatic water measuring tanks on the Marsh-Capron Rail Track concrete mixer.

This mixer was of a one-yard capacity. Concrete was carted from the mixer to the forms. Reinforcing steel was stored between the work and the tracks. Four men were required to supply and operate the mixing plant, while a varying number were used to place the concrete prepared by the mixer.

The Job Laboratory

The job laboratory was the controlling point of the mixing plant. Concrete was secured in buckets as it was about to be deposited in the forms, and carried to the laboratory shed near the office. Here the slump test was made and test cylinders molded to be sent to the laboratory. Absorption was measured by taking a standard sample and heating it over a coal stove. Weighing of the sample was done with a small balance. A set of standard sieves facilitated the check on the fineness modulus of the material reported by the producer. With the above equipment it was found possible to determine absorption and water content to within 0.2 per cent. The sand as received on the work was ordinarily found to contain from 2 to 4 per cent water, while the stone ran to 1 to 2 per cent.

The work was done by the Burrell Engineering & Construction Company, Chicago, for the Chicago, Milwaukee, & St. Paul Railroad. Mr. C. Holland was chief inspector, and S. H. Smith engineer in charge for the owners, acting under F. M. Sloane, district engineer, C. N. Bainbridge, engineer of design, and N. H. La Fountain, general supervisor of buildings, of the railroad.

British Report on Research Into Permeability of Concrete

By A. C. BLACKALL

THE modern Building Research Station, which was recently established at Watford, England, by the British Department of Scientific and Industrial Research, is at present engaged upon a varied program of investigatory work. The station is under the direction of Dr. R. E. Stradling and one branch of the work now being undertaken consists of a very comprehensive series of investigations into the conditions, both in preparation and in use, that affect the extent to which building materials can resist penetration by water. In particular, should be mentioned the study that has been made by W. H. Glanville of the permeability of concrete when subjected to water pressure. Mr. Glanville's study has now reached a stage at which it is worth while to make public the results obtained. The eighth special report on building research, which has just been issued by the department, therefore, deals with the subject.

The permeability of concrete is affected by the nature and proportions of the constituent materials, the methods used in their preparation, and the manner in which they are subsequently treated, including the tests that are applied. Each one of these variable factors has a number of variable sub-factors, and although the present report contains a vast mass of information, and suggests a number of conclusions, it is not submitted as a final statement on the subject.

A normal concrete is made of cement, water, fine aggregate and coarse aggregate, occasionally with the addition in small quantities of a powder which may or may not be chemically inert. The proportions of the solids vary a good deal in practice, but in order to obtain comparable results Mr. Glanville's investigation was carried out principally with a mixture of 1 part cement, 2 parts fine aggregate, and 4 parts coarse aggregate. In order to insure greater accuracy, these proportions were taken by weight and not by volume. Consequently they are not affected by the closeness with which the materials are packed in mixing. The conclusions quoted in this review refer, except when an express statement is made to the contrary, to this standard formula.

Influence of Water

With uniform ramming, minimum permeability and maximum crushing strength are each obtained by using the quantity of water that produces the smallest volume of concrete. The use of too little water, however, causes a greater increase in permeability than does the use of too much. The influence of water content, which is very marked at the outset, decreases with the age of the concrete, and likewise with the increase of the cement ratio, and as between mixes of different richness in cement the percentage by which a given increase of water increases permeability is approximately the same for all cement percentages. An empirical formula has been established connecting permeability and water content.

Mixes of a normal consistency are not appreciably affected by prolonged ramming, but such action, however, reduces the permeability and increases the crushing strength of drier mixes. For both prolonged and normal ramming the points of minimum permeability and maximum crushing strength occur for one percentage of water. The decrease of permeability obtained by prolonged ramming, however, is inconsiderable, and is probably not worth the extra labor involved. Trowelling the surface has been found to reduce the permeability of dry mixes, but has very little effect on wet mixes. For both wet and dry mixes specimens cast on edge are more permeable than those cast flat. Brushing the surface of a specimen cast on edge with a wire brush practically doubles the permeability.

Effect of Curing

With the 1:2:4 mix cured under water the permeability is high at first and decreases gradually, undergoing comparatively small changes after a month. The permeability of air-cured concrete does not decrease appreciably after 14 days. The most important factor of the permeability of portland cement concrete is its curing, but with high aluminous cement concrete this influence is much smaller. The best concrete is obtained by storing in water and the more nearly this condition is attained the more impermeable is the concrete. This is especially important in the days immediately after mixing. It requires very lengthy periods of water curing to bring the impermeability of a badly cured concrete up to that of one which was properly cured from the outset. With 1:2:4 mixes impermeability produced by good curing is permanent. However, under continued water pressure the difference in permeability produced by even widely different conditions of curing decreases, and permeability due to this cause is consequently less permanently serious than when it arises from other causes. Initially permeability is proportional to pressure, but it decreases to an extent that is also proportional to pressure, so that after a seven-day test specimens tested at 25 lb., 50 lb. and 100 lb. per square inch were of equal permeability. Mr. Glanville ascribes the reduction of permeability during testing to a combination of internal silting, hydration and swelling, to extents that vary respectively with the composition and conditions of test. The silting effect is permanent, the particles being cemented in position.

At high pressures and rates of flow swelling plays a relatively unimportant part in reducing permeability. It is, however, more effective at lower rates. In the absence of pressure, when the water rises by capillary action only and is introduced into the concrete by pure absorption, swelling is the main cause of decreasing permeability. On the other hand, however, the rapid bulk swelling which occurs during the first two days after a concrete specimen has been immersed in water, has comparatively little effect on permeability. When concrete is subjected to water pressure considerable hydration has been found to take place.

E. Lee Heidenreich, doctor of engineering, of the Heidenreich Engineering Company, Kansas City, Mo., has been knighted by his majesty, King Haakon of Norway, for achievements in engineering work pertaining to reinforced concrete. Dr. Heidenreich is a contributor to this paper.

EDITORIALS

Fire Prevention Week

OCTOBER third to ninth is fire prevention week. During this week, more than any other time in the year, public attention will be directed to the great losses incurred from the ravages of fire.

The week presents an unusual opportunity for the concretor to tell his story and the story of the material he works with. If he avails himself of the opportunity, he can further his own interests and at the same time do a work of real benefit to the community. He has a vital message, most appropriately told during fire prevention week.

A preliminary estimate of the fire loss in the United States during 1925 is $570,256,000. This is an average of more than a million and a half dollars per day, or $1,084 for every minute of the year! Ten years ago the fire loss was only $172,000,000. At this proportionate rate of increase, what will be the loss ten years from now?

The concretor is intimately concerned with this matter of fire prevention, for the material with which he deals is as highly fire-resistive as any type of structural material in use. Homes, factories, stores, schools, hospitals and other types of structures can be made highly fire-resistive by the use of concrete. It is only through the construction of this type of building that the national fire loss can be reduced.

Every year home builders are paying more attention to the matter of building their homes fire-safe. Such homes cost but little more and they more than earn that cost in lower insurance rates, to say nothing of the sense of security that comes with the assurance that the owner's home cannot burn. When it is known that somebody's home burns every four minutes, the importance of this precaution cannot be overrated. Little wonder that the construction of concrete homes is gaining year by year.

Other types of structures also have a fire record that presents the strongest kind of an argument for the use of concrete. Each day of the year, on the average, 5 schools, 5 churches, 15 hotels, 1 hospital, 4 warehouses, 96 farms, 6 department stores, 2 theaters and 8 public garages suffer losses by fire. Tests of the severest kinds have shown the fire-resistive qualities of reinforced concrete and concrete masonry construction.

Armed with such facts as these, the concretor can and must enter the lists against the tremendous fire loss. He must work for fair building codes that will permit the use of fire-resistive concrete on a fair basis. He must continually preach the gospel of protection against fire by the use of concrete in building construction. Thus he will increase his own opportunities and will render a valuable service to his community. Fire Prevention Week, October third to ninth, will be a most opportune time to concentrate on this work.

Sales Expansion

THERE are two ways that a products manufacturer can expand his business. The first is to move slowly and promote a bigger market for units in the home town. The second is to take over a wider territory and achieve volume through many small demands over a greater unit of population. The first method, calling for truck delivery, is the slowest and hardest mode of expansion, but it has its advantages to the industry. The second, requiring rail shipments, is far easier but frequently leads to a load of trouble.

The producer who plans to restrict himself to a small territory must go in for a lot of energetic promotion. Great production will not be possible until the building public has learned to think in terms of concrete masonry instead of in terms of other materials. This requires much hard work and a bit of expense for advertising, plus the making of a good product for a sufficient number of years for the good-will factor to make itself manifest. But in the long run the restriction to a small territory can make itself profitable to the industry and to the producer himself.

The second method takes immediate advantage of the ready market that exists in almost every community. It is a limited market, but spread over a number of communities will permit sufficient production to warrant a reasonable price per unit. Rail deliveries are not expensive. There is nothing here, however, to prevent another producer from entering into the same market with a lower priced unit, and the upshot of the affair may be an eventual shrinkage of the sales territory and the ultimate necessity for local promotion that is first required under the other plan of campaign.

If Winter Comes

GIVE thought to winter. Not many months from now the snow will begin to fly and the hibernating type of builder and producer will pack his trunk and move to warmer climes. It's then that the wide-awake man will issue gloves to his workman, stoke up the salamander and the furnace, and begin to reap a profitable harvest at the expense of the man who preferred to go into his winter's sleep.

The man who works the year 'round will find his work requires protection, even in the cool days of early fall. The hardening of concrete is retarded even though the mercury yet stands above the freezing point, and that condition can lead to trouble. Take heed to lay in a supply of salamanders, tarpaulins and the other winter necessities, and do not hesitate to put them to work on the job as soon as the north winds do blow.

Precast Concrete Curb

A Description of the Use and Manufacture of Concrete Precast Curb in New Orleans and in Other Cities—Advantages of Concrete Curb — Specifications — Some Designs Now in Use—Favorable Opinions of City Officials

Precast curbing is one of the recent recruits to the ever-growing ranks of the concrete products. The success achieved with its use in the brief period of two or three years indicates rapid expansion ahead, dependent only on the maintenance of uniform quality standards, the securing of which is the chief end to be served by adopting this method of curb construction.

NEW ORLEANS, largest city now using precast curb, introduced the new product in 1924. Prior to that time stone curbing had a strong hold on the market on account of the variable and often unsatisfactory results secured with concrete combined curb and gutter, cast in place. Local conditions also seemed better adapted to a separate curb than to the combined type.

In New Orleans it was felt that much delay in field work could be avoided, with attendant reduction in costs, if a satisfactory local product could be secured. Shipments of stone curbing could not always be depended upon to arrive on the work during favorable weather, nor was it possible for the contractor to order and have shipped an amount of curbing which would bear close relation to the actual footage installed. With these limitations of stone curbing in mind and recalling earlier experiences with concrete curb cast in place, it was only natural that thought should turn to the possibilities of factory made concrete curb, cast in sections of convenient size.

The principal points which led to the use of precast curb in New Orleans are as follows:

1. Assurance of prompt delivery or delivery at most opportune time.
2. Possibility of setting curb independent of pavement slab or gutter.

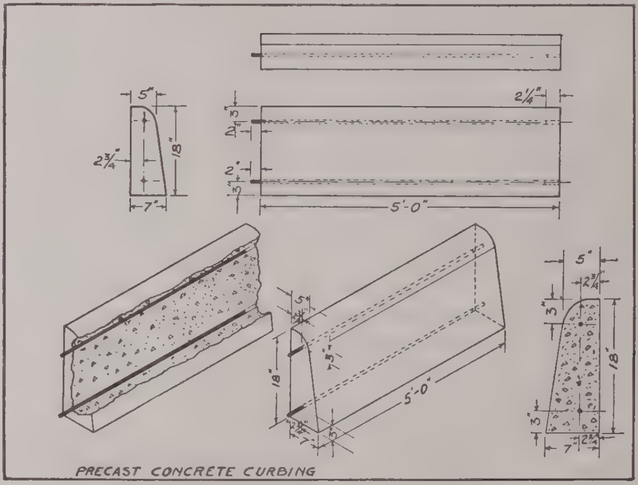
Precast concrete curbs curing in the yard of the New Orleans plant

3. Introduction of an interlocking feature which would assist in overcoming tendency of curbing to subside on the characteristic poor New Orleans subgrade.
4. Proper and uniform materials and methods of mixing, placing and particularly curing.
5. Ease and economy of inspection at factory during manufacture and before delivery, saving time of inspectors and minimizing rejections on work.

Specifications

City Engineer Bryson Vallas states the requirements for precast curbing in the city of New Orleans as follows:

Concrete used in the manufacture of these curbs must have the following volumetric proportions: One part portland cement to two parts sand to three parts of coarse aggregate of such size as will pass through a ¾-inch screen and 90 per cent will be retained on a ¼-inch screen.



Design of precast concrete curb used in New Orleans

Coarse aggregate is trap rock, crushed air-cooled slag or granite screenings with a French co-efficient of wear of not less than 8.

Steel forms are required in order to guarantee true faces and uniformity of all dimensions.

The top and face of the curb are required to have plane surfaces showing no coarse aggregate or pockets.

Curing is done by the saturated steam process, combined with an approved system of water sprayers, for a continuous period of not less than 72 hours, after which, and during temperatures exceeding 60 degrees, the curb is kept moist for 8 days.

Curbing is cast in 5-foot lengths with fractional sections as required. The depth, which is usually 18 inches, may be increased or decreased to meet requirements. The thickness at the top is 5 inches and at the bottom 7 inches, the latter being entirely on the street side of the curb and extending from the nose the entire distance to the base line. The "bull nose" is formed by rounding the upper edge facing the street to a one-inch radius. This surface may be finished by machine or by hand, in order to secure accurate alignment.

In each section of curbing there are placed two longitudinal round reinforcing rods of ½-inch diameter located 3 inches from the bottom and 3 inches from the top, respectively, and 2¾ inches from the back of the curb. These rods are cut slightly shorter than the length of the curb sections and are allowed to protrude about 2 inches on one end. At the opposite end of the sections two holes are provided to receive the exposed ends of the rods in the adjacent section. These holes are 2½ inches deep and the diameter tapers from ¾-inch at the surface to ⅝-inch at the internal end. Exposed ends of the reinforcing rods are painted with red lead and oil. A prepared joint filler, ⅛-inch in thickness is placed between curb sections.

Curb Manufacture

Two concrete products plants located in the city of New Orleans supply local needs for precast curbing. One of these plants uses trap rock for coarse aggregate almost entirely, while the other uses crushed granite. Slag, which was not permitted under previous specifications, is not yet being used, but the city engineering department looks favorably upon this aggregate at the present time, believing that a very hard, tough grade of concrete will be secured with a considerable reduction in weight. The city maintains its inspectors at the manufacturing plant to observe manufacturing operations and curing and to inspect the product as it leaves the plant for the job. Inspection on the job is also maintained but is obviously much simplified by the very effective inspection at the factory.

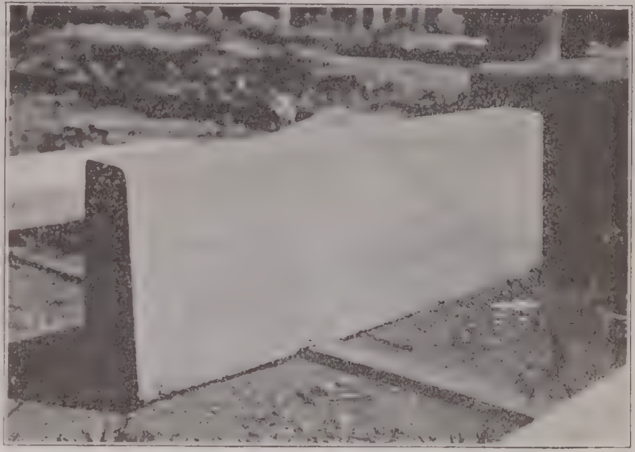
Curved sections of concrete curb used at corners

In commenting on the use of precast curbing in New Orleans, City Engineer Vallas recently wrote:

> "In our experience, precast concrete curbing may be used without hesitancy on the part of the engineer. It may be stated, however, that in our opinion, it is best adapted for use in residential or light traffic streets and unless properly protected, should not be used at circular corners of intersecting streets, or for driveways to be used by steel tired vehicles.
>
> "Our circular concrete curb specifications have been modified so as to permit the use of non-steel protected precast concrete curb for driveways on residential streets, but at street intersections, we find it a more satisfactory job to use the metal protected circular concrete curb, poured in place.
>
> "Since the introduction of precast concrete curbing into our specifications, 147,712 linear feet have been installed, with contracts soon to be started involving approximately 163,222 linear feet.
>
> "We believe that locally the precast concrete curbing has passed beyond the experimental stage and is now considered good standard practice in New Orleans for use as above outlined."

Use in New York Cities

Perhaps some credit for the introduction of factory-made street curbing in New York cities may be given to builders of pavement types competing with concrete. The latter had been using stone from several sources with variation in cost and transportation expense and uncertainty of delivery. Precast concrete was given a trial with the result that today this type is looked upon with a great deal of favor.



A section of concrete curb ready for placing

The principal concrete products factory making precast curb in that vicinity is located in Tonawanda, a suburb of Buffalo. This factory has already supplied several hundred thousand feet of curb for Buffalo, Tonawanda, Lackawanna and other cities in the vicinity. Recent inspection shows curb in use two years or more under heavy traffic is still in the same condition as when set. Local engineers and paving contractors are enthusiastic over precast curbing, the former because of ease of inspection,

The concrete curb in place

good appearance and ease of moving or re-aligning and the latter because it speeds up construction and shifts responsibility for quality without increasing cost.

The precast curbing manufactured at Tonawanda varies from that made in New Orleans principally in the matter of size and proportions. Standard sections are 4 feet in length with several fractional sizes provided of which 19 inches is the shortest. The depth is 18 inches in all cases, about 10 inches being placed below grade and 8 inches above grade. The type now being supplied to Tonawanda and Lackawanna have a thickness of 6 inches from base to grade line, the face of the curb being battered from this point to the top. The thickness across the top is 5 inches. The rounded nose of the curb is protected with standard galvanized steel nosing anchored securely in the concrete several inches below the surface. The practical use of this nosing is now seriously questioned, some of the engineers feeling that it is just as well omitted from regular straight sections. It is specified specially in the few places where needed. It is felt that the steel is rarely of value except where steel tired vehicles are customarily backed against the curb. The reinforcing in each section consists of an electrically welded mat of square mesh with ⅛-inch members 3 inches apart in both directions. The reinforcing is placed on the center plane of the sections. This curbing weighs 100 pounds per lineal foot and is easy to handle and to reset where necessary.

A similar type has been supplied in the city of Buffalo recently which is somewhat lighter, having a uniform thickness of 5 inches from bottom to top, being without batter. Another type has been suggested recently which has a 2-inch batter and a round nose formed to a 2-inch radius, in order to protect both curb and tire against injury from wheel contact. It is suggested for use without steel nosing. Both of the latter types are reinforced in the same manner as the former one and all three have lower end corners battered as shown in the illustrations, to simplify alignment and removal. The sections are laid without space or filler between.

The mixture used in the manufacture of these curbs is 1:2:3, with torpedo sand and gravel running up to 1 inch in size. The consistency used is just sufficiently wet to work the material into place in the molds with the assistance of motor-driven agitator. The above mixture and consistency are relied upon to produce concrete testing above 3000 pounds per square inch of area.

Wooden molds are used, the curb sections being cast with base up. Circumferential sections are made from special layouts and are cast face up in flat wooden molds. The sides of these molds are cut to the required curvature and the face shaped with a wooden template. The sections are removed from the molds at the end of 24 hours and stored for 30 days or longer in large rooms where the atmosphere is kept warm and moist.

July Construction Breaks All Records

All records for volume in construction in the United States were shattered in July. Never before was so much money expended in a single month for labor, materials and other elements entering into building costs, according to statistics compiled by the Associated General Contractors of America.

The volume of construction handled last month was well above that recorded for August, 1925, when the previous "peak" was reached. The index on construction operations, based on the 1913 average, shows a jump from the March level of 120 points to the present position of 229. This is the greatest increase within a four-month period ever recorded.

The construction work under way last month furnished a total 4 per cent greater than that shown in June.

The total volume of construction performed during the first seven months of 1926 was 4 per cent greater than the amount registered during the corresponding period last year. This fact assumes added significance, it is stated, when consideration is given to the trend of operations earlier in the year. Until the end of April, operations lagged behind the figures set at corresponding stages in 1925. It was in May that the present phenomenal spurt started.

Lumnite Cement Used in Raising Sunken Submarine

An unusual use of quick hardening cement was described by Commander Elsberg in telling of the difficulties encountered in raising the sunken submarine S-51 to a group of engineers at the Engineer's Club in New York.

For two hours Commander Elsberg held his audience by a story that was as dramatic as it was educational. Commander Elsberg told of burning away portions of the steel deck of the submarine with torches 135 ft. under water; of washing tunnels with a fire stream through hard clay under the submarine, the tunnels only large enough for a diver to lie prone in; of one of these tunnels caving in back of the diver and of his washing space in which to turn and then washing his way out through the cave-in.

Of particular interest to engineers and construction men who have at times used cement grout in their construction work was Commander Elsberg's description of making the undamaged compartments of the submarine tight so that the water might be expelled by compressed air. To effect this, the speaker pointed out that scores of valves inside of the submarine had to be closed by divers. This was done after a thorough schooling and rehearsal on a sister ship, the S-50. Two large flap valves on 24-inch ventilating ducts offered a serious problem, as it was impossible to fasten these valves closed against an internal air pressure.

After all attempts to seal the two large valves by fastening the flap shut had failed, it was decided that they could be sealed only by filling them from the surface with some material which would solidify and make them air tight. Experiments under simulated conditions with a number of materials, including the ordinary cements in common use, showed these materials to be not entirely satisfactory or sure of success. Experiments with quick hardening lumnite cement showed that this war time product would harden quickly under the deep sea conditions involved. After Commander Elsberg determined this, divers inside the submarine tapped holes in the large valves and attached 1¼-inch valve connections for a heavy rubber hose leading out of the submarine and up to the rescue ship "Falcon". On board the "Falcon" the lumnite cement was mixed with water in proportions of two of cement to one part of water in a heavy steel tank. The tank was then closed and 150 lb. of air pressure applied to force the grout through 250 ft. of hose to each of the flap valves.

After the cement had been allowed to harden for two days, it was found that the undamaged compartments were then air tight and the water in them was readily expelled by compressed air. This furnished sufficient buoyancy to make it possible to lift the submarine with eight large pontoons. Commander Elsberg explained that if the compartments of the ship could not have been made air tight, it would have been impossible to have provided sufficient buoyancy through the use of pontoons to have moved her.

Wide Highways of Concrete

When modern traffic conditions require wider highways it is but natural that concrete is the material adopted for the widening. As is shown in these photographs, the concrete strip conserves the investment in the original permanent concrete pavement, for it is but a natural and fitting addition thereto

Cahuenga Pass Highway, Los Angeles County, California. Originally paved to a width of 36 feet in 1925, it was widened to 72 feet the following year

The historic Boston Post Road, passing through Fairfield County, Connecticut, has been paved with reinforced concrete to a width of 36 feet

The Albany Post Road, another famous highway leading out of New York City, has been paved with concrete, in Westchester County, and widened to 36 feet in 1925, a year after the original pavement was completed

The Lincoln Highway, near Ardmore, Pennsylvania, was originally paved to an 18 foot width, and later widened by the addition of two 10 foot concrete shoulders

The Five Mile Road, in Wayne County, Michigan, was originally paved with a width of 20 feet. Another strip of equal width will turn this stretch into a 40-foot concrete highway

Here and There

Some Random Notes on Visits with Concretors in the Field

THERE are many things to be seen and heard when the editors tune up the old chariot and turn her radiator cap toward the field to see what there is to see and hear what there is to hear in the concrete industry.

"WHY Products Manufacturers Fail" would be one theme on which such a journey of interrogation furnishes a world of material. Here we were, driving through the most prosperous country of the great Middle West. Everywhere people were building, but they were using almost every material but concrete block and tile. We wondered why. The reason was not hard to find—not nearly as hard as it was to find the concrete products manufacturer in these prosperous towns. Usually he was somewhere in the back end of an old, abandoned shack in a forsaken part of town. Nobody knew of him and nobody knew of his product. That is reason No. 1 in the theme.

Then when we did find him, reason No. 2 was evident at first glance. One look at the plant and all confidence in the material it would produce was shattered. Untidy yards with broken block and tile strewn about to impress you with the fact that this was not a desirable material to use for a home that was supposed to last for a few years at least. Inside was a hand block machine. If you were lucky, you would find the proprietor who usually was also the "force". Then in conversation with him you would find reasons Nos. 3, 4, 5 and so forth up to infinity.

For almost a thousand miles of travel these were the conditions. It was easy then to see why 80 per cent of the concrete products manufactured are being made by 20 per cent of the plants.

"WHY Products Manufacturers Succeed" would be another theme upon which the journey yielded a wealth of information. Reason No. 1 was found at once in several visits. Here was a brand new products plant. It was on one of the principal streets connecting the business section with the industrial section of an important city. Thousands of people passed there every day. A neat, businesslike building of concrete block housed the establishment. On the lawn in front of the building was an interesting display of block, brick and trim stone, attractively arranged. That looked good, so we decided to talk to the boss.

"Yes, that display helps us a lot," he said. "People stop there often on their evening drives. We have derived a lot of business from it. You bet," he continued, "we sell on quality. The first thing we did was to send in some blocks for tests and got our Certificate of Quality. We sell the architect and the contractor a strictly high-grade block and they are coming back for more. Yes, sir, business is good and it will be better. You know, we have just started." And with that he gave us any number of reasons why products manufacturers succeed.

THEN we came to a town where about the only products man we could find manufactured concrete pipe. And he told us his story.

"Concrete pipe manufacturers are overlooking a good bet," he told us. "We are about the only outfit making pipe in the 4, 6 and 8-inch sizes in spite of the fact that the clay pipe of that size constitute 75 per cent of the clay pipe made. The concrete fellows better get busy on that field. There is a big market for them in pipes for house connections. There hasn't been a carload of clay tile in this town for more than three years."

CONCRETE brick came in for a share of attention, too. In one city we found a concern that is making a lot of good brick and what is more, they are selling it. They realize the value of getting into the swim with the business men in that city and figure that personal contact with the "powers that be" helps to sell even concrete brick. They have a dandy plant in which the aggregates are measured by weight and everything is arranged so that making the brick costs as little as possible for labor.

One of the officials of the company is the operating man and his job is to turn out a lot of good brick. Another man looks after the selling end, and he is doing that so well that the plant can hardly keep up with him.

BUT the most interesting use of concrete brick was found in one of the universities along the route. Here the superintendent of the university buildings sold himself on concrete brick and is using it in the new buildings now being erected by the university. Two of the new buildings each used more than 2,000,000 of the brick.

The superintendent of buildings got all enthusiastic about these same concrete brick and we could hardly get a word in edgewise while he was telling us about them. He uses them for the inside walls of laboratory buildings and they certainly look fine when they are laid up carefully with a nice true white mortar joint.

"Yes, sir, gentlemen," says this learned enthusiast, "concrete brick have acoustic properties that are of the highest order. There is no annoying reverberation when the walls are covered with them. And in our large lecture rooms you can hear every whisper of the lecturer way back to the last row of seats."

And to prove it he takes us to one of the great big lecture rooms. Away down yonder was the instructor talking to a handful of students. He was talking very low, but we could hear every word and both of us are no great shucks at hearing.

Then we went to the university brick plant. The superintendent of buildings makes the brick himself and when the buildings are erected by contract, he sells the contractor his bricks at cost.

OF course, on these jaunts we visit a lot of construction jobs. We call on bank presidents and mixer men, on cement manufacturers and cement users. The things we see and the things we hear are being passed on to you in articles from time to time. Who can tell? Perhaps you will be the next man we will call upon.

The Constitution of Portland Cement Clinker*

Part III of a Digest of the Literature on the Subject—Methods of Developing Early Proportioning Formulas—Experiments with Various Materials—Advantageous and Harmful Elements—Making Experimental Cements—Researches of Le Chatelier, S. B. Newberry, W. B. Newberry, J. L. Duchez, Jean Hendrickx and Others—Many Formulas Studied

By R. H. BOGUE

WITH the experiments and researches of Henri Le Chatelier, about 1887, the scientific method of research in the constitution of portland cement clinker was inaugurated.

Previous to the work of Le Chatelier, many scientists of note had given of their time to the general subject of cement and its uses, which subject was beginning to attract the attention of scientists and engineers in many countries. But as yet no definite principles were agreed upon. Investigators up to that time were principally concerned with the use of the material rather than with the material itself.

LE CHATELIER, with his keen perception and thorough work, succeeded in discovering and tabulating many findings which are today acknowledged as facts. With the crude equipment available at that time he studied and tabulated the various chemical combinations that occur in portland cement and even ventured opinions as to what were the chief hydraulic constituents of cement. He was the first to apply the microscope consistently to this problem and with its aid he classified the principal constituents of clinker.

Following Le Chatelier, came other scientists, also working on the same problem. Their work and the results they secured were described in Part II of this series of articles on "The Constitution of Portland Cement Clinker."

THE discoveries described in Part II led to the "Development of Proportioning Formulas," which is the subject discussed in Part III of the series, published in this issue.

Part III.—Development of Proportioning Formulas

Henri Le Chatelier

LE CHATELIER[19] was among the first to propose definite formulas for proportioning the raw mixture in terms of the principal oxides, CaO, MgO, SiO_2, Al_2O_3, and Fe_2O_3. On the basis of his previous investigations on constitution, it seemed altogether justifiable to Le Chatelier that the composition of clinker should be rigorously defined by two limits for lime. The clinker should not, he argued, contain any free lime, as this produces unsoundness in the product. That is, the molecular ratio $\frac{CaO}{SiO_2}$ must not be greater than 3, since the tricalcium silicate, $3CaO.SiO_2$, is the most basic of the silicates in cement. On the other hand, the presence of too great an amount of the dicalcium silicate, $2CaO.SiO_2$, seemed undesirable to Le Chatelier since he believed that he had found this compound to disintegrate spontaneously (dust) and to be non-hydraulic. When an excess of lime is present, he believed the compounds formed to be $3CaO.SiO_2$ and $3CaO.Al_2O_3$. Thus the upper limit for CaO in which the assumption is made that Mgo may replace CaO, is expressed by:

$$\frac{CaO + MgO}{SiO_2 + Al_2O_3}$$

not greater than 3.

But as CaO decreases, Le Chatelier assumed that silico-aluminates of unknown composition separate out. Following this, the $2CaO.SiO_2$ appears. If the formula for the silico-aluminate is assumed to be $3CaO.Al_2O_3.2SiO_2$, then the lower limit for CaO, in which $2CaO.SiO_2$ will just fail to appear will be $\frac{CaO + Mgo}{SiO_2 — (Al_2O_3 + Fe_2O_3)}$ not less than 3. Here the Fe_2O_3 is assumed to be capable of replacing Al_2O_3. Hence in the formula $3CaO.Al_2O_3.2SiO_2$, $SiO_2 - (Al_2O_3 + Fe_2O_3) = 1$, $CaO + MgO = 3$, and the ratio expressed $= 3$. If this falls below 3, therefore, Le Chatelier argued that the "undesirable" $2CaO.SiO_2$ would be formed. In numerous cements examined, those of good quality were found consistently to conform with these formulas, while those of poor quality departed from them.

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*Paper No. 3 of the Portland Cement Association Fellowship at the Bureau of Standards.

[19] Henri Le Chatelier, "Experimental Researches on the Constitution of Cements and the Theory of Setting." *Compt. rend.*, 94 (1882), 13; *J. Soc. Chem. Ind.*, *1* (1882), 151. "Experimental Researches on the Constitutio of Hydraulic Mortars," traslated by J. L. Mack, New York, 1905.

As a matter of fact, the ideal condition of a clinker consisting exclusively of $3CaO.SiO_2$ and $3CaO.Al_2O_3$ is probably never attained in practice due to a lack of fineness or homogeneity of the raw mix, and insufficient temperature or duration of burning. The additional cost necessary to attain the ideal cement appears to be out of proportion to the advantage gained. It is therefore preferable, according to Le Chatelier, in order to avoid the presence of free lime, to increase the content of silica and alumina, forming some inert silico-aluminate. Even with these precautions, he believes that some free lime may remain in the clinker, due to large grains of limestone or inhomogeneity of mixing. He advises that this free lime should be slaked prior to use by exposure to air or other means.

S. B. and W. B. Newberry

S. B. and W. B. Newberry[30] point out, however, that while the formulas of Le Chatelier conform closely with the practical results of cement manufacture, they fail to distinguish between the lime requirement of a clay rich in silica and that of a clay rich in alumina.

The Newberrys attacked the problem in an empirical manner rather than by deduction from theory. They determined the upper limit for CaO by means of the *hot test.* They claimed to be able to observe an excess of lime as small as 1 per cent by noting if expansion or cracking occurred on placing a pat of set neat cement in steam for 4 or 5 hours.

Mixtures of pure chalk, ground quartz and alumina were mixed and burned at "white heat." The mixture $2CaO + SiO_2$ dusted completely when cooled slowly but did not dust when quenched in water. The non-dusted portion gave a sound, slow setting product of satisfactory hardness in 1 and 7 days.

The mixture $2\frac{1}{2}$ $CaO + SiO_2$ did not dust, gave a sound pat, but set slowly and hardened very slowly.

The mixture $3CaO + SiO_2$ did not dust, gave a sound pat, set fairly in one day, but did not harden for several weeks.

The mixture $3\frac{1}{2}CaO + SiO_2$ did not dust, and the pat set hard but left the glass and cracked. The Newberrys believed combination to have been complete in all cases, but concluded that the slow setting and hardening qualities of the more basic mixtures rendered them somewhat inferior. The $2CaO + SiO_2$ product alone was satisfactory from the point of reasonably rapid hardening, but its presence made dusting probable.

The mixture $2CaO + Al_2O_3$, heated strongly with water, set in a few seconds and was sound.

The mixture $2\frac{1}{2}CaO + Al_2O_3$ gave a pat that left the glass and cracked and did not harden well.

The mixture $3CaO + Al_2O_3$ also gave a pat which curved and cracked and disintegrated slowly in water.

On the basis of these investigations, the Newberrys concluded that $3CaO.SiO_2$ and $2CaO.Al_2O_3$ are the most basic compounds which can exist in good cements. They accordingly proposed the formula:

$$x\ (3CaO.SiO_2) + y\ (2CaO.Al_2O_3)$$

in which x and y vary in accordance with the relative amounts of SiO_2 and Al_2O_3 present. On preparing synthetic cements in accordance with the above formula, in contradistinction to that of Le Chatelier,

$$x\ (3CaO.SiO_2) + y\ (3CaO.Al_2O_3),$$

they found their own to apply, while, by the latter, the excess of CaO required to combine with the Al_2O_3 as $3CaO.Al_2O_3$ over that required to combine as $2CaO.Al_2O_3$ was found to remain in the free state so far as could be inferred from the steam test. The product was unsound in all cases, and increasingly so as the Al_2O_3, and consequently the excess CaO, was increased.

Comparison of Experiments

Le Chatelier had contended that mixtures of CaO and Fe_2O_3, on burning, gave products that were not at all hydraulic. Schott, on the other hand, had found that Al_2O_3 could be replaced completely by Fe_2O_3 without detriment to the hydraulic character of the cement. Newberry burned a mixture of $2CaO + Fe_2O_3$ and found the product to be inactive in the cold, but to harden rapidly in steam and to be sound. A mixture of the composition $3\ CaO.SiO_2 + 2CaO.Fe_2O_3$ containing 7 per cent Fe_2O_3 was found to be slow setting, sound, and hard.

A number of mixes were burned in which the Fe_2O_3 was proportioned as follows:

$$x\ (3CaO.SiO_2) + y\ (2CaO.Al_2O_3) + z\ (Fe_2O_3)$$
$$x\ (3CaO.SiO_2) + y\ (2CaO.Al_2O_3) + z\ (2CaO.Fe_2O_3)$$
$$x\ (3CaO.SiO_2) + y\ (3CaO.Al_2O_3) + z\ (3CaO.Fe_2O_3)$$

The percentages of Al_2O_3 and Fe_2O_3 were 4 and 3 respectively. The first two mixtures gave entirely satisfactory products and no difference was observed between them. This demonstrates, according to the Newberrys, that in cements of ordinary low-iron clays, no account need be taken of the Fe_2O_3 content in calculating the lime requirement. This was a confirmation of the view held by Le Chatelier. The third mixture gave an unsound product indicating that it contained an excess of lime.

The influence of Na_2O and K_2O was studied by burning mixtures analogous to the compositions $3CaO.SiO_2 + Na_2O$ and $3CaO.SiO_2 + Na_2O.SiO_2$, using 5 per cent Na_2O. In neither case did the Na_2O render more complete the combination of the CaO and SiO_2, as shown by the unsoundness of the pats. The Newberrys conclude that the alkalies are incapable of aiding combinations containing a large proportion of CaO.

Magnesia was studied to determine if it could replace lime in cements and if account need be taken of it in calculating the mixture. Pure silica and alumina with various amounts of MgO were burned but in all cases the products were lacking completely in hydraulic properties. They failed to harden in water, air or steam.

A mixture was next prepared in accordance with the formula:

$$x\ (3MgO.SiO_2) + y\ (2MgO.Al_2O_3)$$

After burning at a high temperature, a product was obtained which contained 10.14 per cent insoluble residue (Lunge's method†) while the same mixture prepared with CaO in this formula in place of MgO left only 0.4 per cent insoluble residue. From this, the Newberrys conclude that MgO combines with the silica and alumina of clay to a much less extent than does CaO.

A mixture was then prepared, using dolomitic lime, in which enough CaO was present to combine with the SiO_2

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[30] S. B. and W. B. Newberry, "The Constitution of Hydraulic Cements," *J. Soc. Chem. Ind., 16* (1897), 887.
"Studies on the Constitution of Hydraulic Cements," *Cement Eng. News, 13* (1906), 67.
"The Proportions of Cement Mixtures, *Cement Age, 2* (1905), 76.

†This method consists in digesting the product of the calcination alternately with 20 per cent hydrochloric acid and 20 per cent sodium carbonate solutions. By this treatment the lime, and the silica which has been rendered soluble, are dissolved, while the uncombined silica remains unattacked.—*Tonind. Ztg.* (1894), 655.

and Al_2O_3, leaving the MgO unaccounted for. This product was sound, hardened well and appeared quite satisfactory although the ratio $\frac{CaO+MgO}{SiO_2+Al_2O_3}$ was 4.16, a value greatly in excess of the maximum permitted by Le Chatelier's formula in which the MgO is assumed to act as CaO.

The hydraulic index,

$$\frac{SiO_2 + Al_2O_3}{CaO + Mgo} \times 100 = 42 \text{ to } 48,$$

had been proposed by Vicat but the Newberrys point out that it is not consistent with the dissimilarity of CaO and MgO. Objection is also raised to the hydraulic modulus of Michaelis,

$$\frac{CaO}{SiO_2 + Al_2O_3 + Fe_2O_3} = 2.2,$$

on the basis of the incorrect assumption that SiO_2, Al_2O_3 and Fe_2O_3 combine with CaO with equal avidity. Le Chatelier and others have shown that, in actual practice, the most basic silicate of constant volume contains 2.8 parts by weight of CaO to 1 of SiO_2 and the most basic aluminate 1.1 of CaO to 1 of Al_2O_3. Hence the ideal formula was suggested:

$$CaO = 2.8\,SiO_2 + 1.1\,Al_2O_3$$

If we substitute 1 for 1.1 Al_2O_3, and substitute 2.7 for 2.8 CaO, since the latter represents a maximum value, the Newberrys obtain their practical formula, expressed as percentage by weight:

$$\frac{CaO - Al_2O_3}{SiO_2} = 2.7.$$

Close agreement with practice was found to obtain by this formula.

In 1916 (l. c.) S. B. Newberry modified slightly the above formulas in accordance with his acceptance of the work reported by Rankin (Cf. Chap. VII). Thus the formula giving the maximum lime content, and assuming that all of the lime, silica and alumina are in the form of tricalcium silicate and tricalcium aluminate, would be:

$$x(3CaO.SiO_2) + y(3CaO.Al_2O_3).$$

This is similar to Le Chatelier's formula, eliminating MgO from the calculation. Newberry points out, however, that with the ordinary temperature and time of burning this would give too much lime and produce an unsound cement. He assumed that four-fifths of the silicate may be regarded as going to the tricalcium silicate and one-fifth to dicalcium silicate. This gives the formula:

$$x(2.8CaO.SiO_2) + y(3CaO.Al_2O_3),$$

and substituting weights for equivalents,

$$CaO = 2.6SiO_2 + 1.6Al_2O_3.$$

Newberry states that this formula, applied to ordinary cement materials, gives almost exactly the same proportions as the original formula given above. Under working conditions, Newberry finds it safer to reduce the CaO slightly below the factor 2.5, in order to counter-balance defective grinding of the raw material or unavoidable variations in composition. The final practical formula is thus given:

$$CaO = 2.5SiO_2 + 1.6Al_2O_3.$$

He urges that a *lime factor*, expressed by the relation

$$\frac{CaO - 1.6Al_2O_3}{SiO_2} = 2.5$$

"will give cements of practically maximum quality with any materials, whether silicious or aluminous, provided the mix is finely ground and properly burned."

Jean Hendrickx

Jean Hendrickx[31] of France has published many papers in which he takes exception to the formulas of earlier investigators on the ground that they represent a rather special case where complete combination is effected, and fail to consider the very important distinction between fusion and clinkerization. Michaelis had previously urged the necessity for making this distinction:

> The properties of cement clinker do not depend solely on the chemical composition. The experiences which one attains with a certain raw material of a given composition may not apply necessarily to another material of the same composition. The results consequently may not be generalized except in a very limited measure. In crystallized cement, on the other hand, we have a product in which the constituents have been rendered capable of complete combination by the integral fusion. The proportions of the products depend on the chemical composition, the duration of heating, and analogous factors as the presence of impurities.

This viewpoint formed the basis of much of Hendrickx' work on cements. He writes:

> In fusion, the value of the product depends only on the elementary composition. Here the current formulas serve their purpose. In clinkerization, the value of the product depends on three factors:
> 1. The chemical composition
> 2. The physico-chemical state of the constituents
> 3. The temperature and period of burning.

Hendrickx maintains that there exists an upper limit for lime representing the theoretical maximum based on the absolute combining capacity of the lime for the silica and other constituents. But this limit, which he calls the *upper limit of affinity* is not always attainable in commercial kilns, due to the high temperature which may be required, except the content of flux be just right. He therefore defines a second limit which he calls the *upper limit of burning* as that beyond which normal burning becomes difficult, if not impossible, under ordinary conditions of operation. He claims that a conformance of the first limit gives rise to a cement always perfect if the burning has been suitably conducted, but that under ordinary conditions the second limit must be observed.

The major problem of the cement chemist, therefore, becomes that of causing the first limit to coincide with the second. There are some clays, he states, in which the affinity limit is higher than the burning limit; after burning with the theoretical amount of limestone they still contain free lime. But there also are clays in which the two limits are identical. These burn easily and in extreme cases fuse in the kiln.

Hendrickx' Conclusions

In consequence of these postulations, Hendrickx concludes:

> All systems of proportioning must include two categories of tests, entirely distinctive. First, those which are concerned with the composition of the mix from the point of view of the proportions of the constituents, and second, those which deal with the efficiency of the burning of the mix thus proportioned. . . . It is essential that the two categories of tests go together and that their results balance and compensate each other.

Hendrickx appears not to be at all concerned over the exact manner of combination of the CaO and SiO_2, but believes that solid solutions are easily formed. He thinks it is probable that the principal constituent of clinker is a compound intermediate between the di- and the tricalcium silicates. He states:

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[31] Jean Hendrickx, "Cement of High Strength" *Chemie & Industrie 8* (1922), 296. "The Manufacture of Artificial Portland Cement," Paris, 1922.

> The compound $2.5CaO.SiO_2$ may be regarded as underburned calcium silicate, $1.5CaO.SiO_2$, with one molecule of CaO in solution, or as dicalcium silicate with one-half molecule CaO in solution, or as a mixture of equal parts of di- and tricalcium silicates, or as a mixture of two molecules of tricalcium silicate and one molecule of underburned calcium silicate, or as still other combinations.

The essential thing to Hendrickx is not the manner of combination, but the ratio in which the silica and lime must be proportioned. And according to him this appears to be in the ratio of the hypothetical compound $2.5CaO.SiO_2$. The alumina and iron oxide he believes to be present as the tribasic salts. He accordingly writes the general formula for cement:

$$x\,(2.5CaO.SiO_2) + y\,(3CaO.Al_2O_3) + z\,(3CaO.Fe_2O_3).$$

In applying the formula it is necessary to multiply the weights of "soluble silica" by 2.33, of alumina by 1.65 and of iron oxide by 1.05 to obtain the quantity of lime required, as these factors represent the ratios indicated in the formulas. Finally there should be made the necessary corrections for the presence of magnesia and sulphuric anhydride. This he does by deducting, from the total of lime already obtained, 56/40 of the magnesia and adding 56/80 of the sulfuric anhydride, in accordance with the hypothesis that the SO_3 combines with the lime as $CaSO_4$ and that the MgO substitutes for the CaO in proportion to their molecular weights. If it is desired to convert the factors for CaO into factors for $CaCO_3$ in the raw mixtures, there is obtained, for silica, the factor 4.1; for alumina, 2.94; and for iron oxide, 1.87. Since the oxides R_2O_3 are rarely considered separately in the raw mix, one may take for the sum of the two oxides a factor proportionate between 2.94 and 1.87 such that there is expressed the most usual relation between the alumina and the iron oxide; he gives this the value 2.6 corresponding to two parts of alumina to one of iron oxide.

Thus there is obtained the formula:

$$CaCO_3 \text{ required} = 4.1 \times SiO_2 + 2.6 \times R_2O_3 \text{ by weight.}$$

These formulas were found by Hendrickx to be entirely satisfactory when applied to a large variety of materials.

J. L. Duchez

A formula developed by J. L. Duchez[32] is similar to that of Hendrickx except that the former considered the ratio of lime to silica in the silicate to be 2.35 to 1. Thus the formula:

$$x\,(2.35CaO.SiO_2) + y\,(3CaO.Al_2O_3).$$

Duchez obtains this figure and evaluates x and y in the following manner: The analysis of a large number of cements gave the value:

	Limits per cent	Average per cent	Average molecular ratio
SiO_2	20.04 to 26.10	23.07	3.84
Al_2O_3	4.86 to 10.60	7.73	0.75
Fe_2O_3	2.10 to 5.30	3.70	0.24
CaO	57.42 to 67.30	62.36	11.30
MgO	.33 to 4.96	2.64	0.66
SO_3	.26 to 2.00	1.13	trace

By considering the iron oxide as alumina, and the magnesia as lime, the sum of the substances will be:

$$3.84SiO_2 + 0.99Al_2O_3 + 11.96CaO$$

If the Al_2O_3 goes to $3CaO.Al_2O_3$, the $0.99Al_2O_3$ will require $.99 \times 3 = 2.97$ CaO and there will remain $11.96 - 2.97 = 8.99$ CaO available to combine with SiO_2. The coefficient for SiO_2 being 3.84, that for CaO will be $8.99/3.84 = 2.35$, so the formula for the silicate becomes $2.35\,CaO.SiO_2$, and the cement so obtained would have the formula:

$$3.84\,(2.35CaO.SiO_2) + 0.99\,(3CaO.Al_2O_3)$$

On the other hand, if the silicate is regarded as dibasic, there would result the formula:

$$3.84\,(2CaO.SiO_2) + 0.99\,(3CaO.Al_2O_3) + 1.31\,CaO$$

and if tribasic, the formula:

$$3.84\,(3CaO.SiO_2) + 0.99\,(0.44\,CaO.Al_2O_3).$$

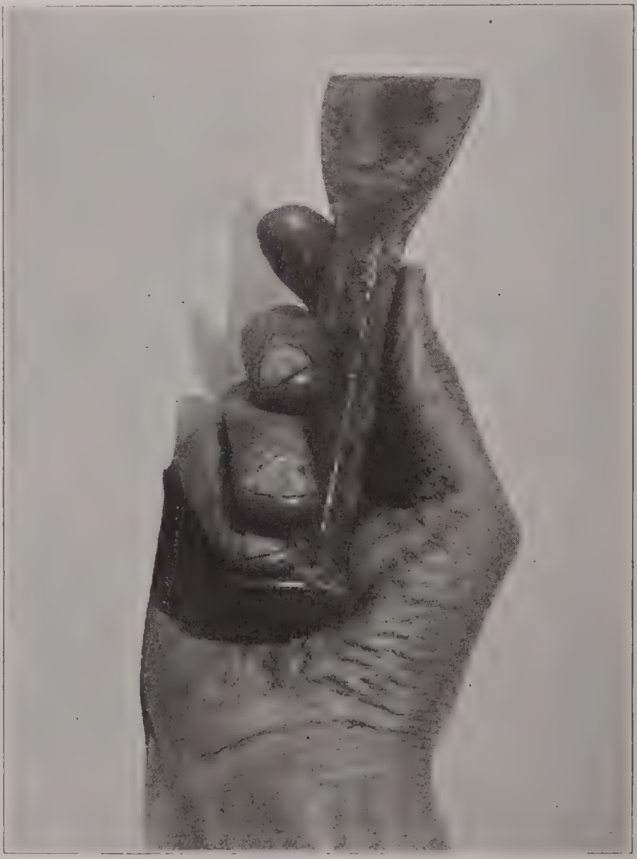
In the one case there seems to be an excess of lime remaining free in the cement, and in the other case, an insufficiency of lime to form $3CaO.Al_2O_3$. Duchez prefers to believe that free lime may be present, and that this may dissolve in the $2CaO.SiO_2$ to form a substance of a composition approximating $2.35\,CaO.SiO_2$.

Many other proportioning formulas have been proposed from time to time but those described above represent perhaps the work best known and most generally accepted on this phase of cement research.

Part IV of this series, "Hypotheses of Solid Solution," will appear in the October number of CONCRETE.

A Real Cleaning Tool

The photograph shows how an old and discarded rail spike can be made into an excellent cleaning tool. By flattening the end and scarfing it, a very good scraping edge is procured. Note how the head of the spike rests nicely in the palm of the hand where the pushing of the tool can be effected with least exertion. The lip of the head converts it into a "baby" adz for knocking off small bits the scraper or other end cannot conveniently loosen. It is not too heavy, yet is what might be termed a "he man" tool for cleaning dirt and cement covered tools.



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[32] J. L. Duchez, "Constitution of Portland Cement," translated by C. S. Darling, *Rock Products*, *26* (1923), No. 16, 28; No. 18, 33; No. 20, 46; *27* (1924), No. 7, 37; No. 14, 29; No. 22, 36; No. 25, 24; *28* (1925), No. 1, 56; No. 8, 45; No. 16, 48; No. 20, 50.

Device for Measuring Pressure Used in Molding Briquettes

New Instrument Perfected by Government Engineers to Control Uniformity of Tests by Insuring Uniform Pressure in Making Cement Mortar Briquettes

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The pressure exerted by the operator in molding the standard 1:3 cement mortar briquette probably has as great an influence on the tensile strength as any other single factor. Notwithstanding this fact, the present standard methods of testing portland cement do not provide for the application of any definite pressure, the matter being governed by general reference only. This naturally has resulted in considerable variation in the technique employed by different operators and probably has accounted in part, at least, for the wide divergence in strength tests frequently reported when identical samples are tested in different laboratories.

Recognizing the desirability of controlling this as well as many other details of procedure subject to personal interpretation, the American Society for Testing Materials prepared and published a year ago a "Manual of Cement Testing," in which the various methods of testing were described in much greater detail than in the specification proper. In that portion of the manual referring to the molding of briquettes, a pressure of 15 pounds applied to the surface of the briquette was suggested. This value was taken by the committee from the recently proposed master specification for portland cement of the United States Government and was probably suggested originally by the United States Bureau of Standards. Practically the same pressure, modified so as to call for a minimum of 15 pounds and a maximum of 20 pounds, is provided for in the new tentative specification for portland cement of the American Society for Testing Materials, adopted provisionally at the June, 1926, meeting. This specification, if adopted by letter ballot of the society, as it probably will be, will automatically become the new American Society for Testing Materials standard some time before the close of the present calendar year.

In the new specification, the requirements for tensile strength of briquettes have been raised from 200 pounds per square inch to 225 pounds per square inch at seven days and from 300 pounds per square inch to 325 pounds per square inch at 28 days. This increase in the strength makes it all the more important that the technique of testing, in so far as those factors which influence the strength are concerned, be very rigidly controlled. The new values represent more nearly the true tensile strength of many normal portland cements than the old, so that incorrect methods of testing, which tend to give low results, will undoubtedly cause more rejections. Then, too, it is well recognized that many operators, especially those of long experience, have become accustomed to using a pressure considerably greater than that provided for in the new specification. Under the proposed specification, these operators will be required to use a pressure of from 15 to 20 pounds, which will undoubtedly result in lower strengths being reported, still further reducing the factor of safety.

New Instrument Designed

Anticipating the need of a simple yet fairly accurate device for measuring the pressure exerted in molding briquettes, the Bureau of Public Roads has designed an instrument for this purpose.[1] The instrument consists essentially of a platform to support the briquette mold, resting upon a multiple lever system which operates against a small coil spring. Two contact points are so arranged on the lever arm that the degree of compression of the spring is indicated by the closing of one or both of two lamp circuits. The initial compression of the spring may be varied so that pressures of from about 10 to 40 pounds may be registered.

A detailed drawing of the instrument is shown in Figure 1, reference to the various parts being indicated by letter. In this drawing, *A* represents a three-gang briquette mold resting upon a glass plate, B, which in turn rests upon the platform of the instrument, D. The pressure exerted is transmitted through the knife edges and hardened bearings, *F*, mounted on the transmitting levers, *G*, which have steel ribbon supports, *H*, and steel knife edge points *I*, resting upon the operating lever, *J*. This lever has a steel ribbon support, *K*, at one end, and at the other end, a fiber insert, *L*, carrying three screws, the center one connected by wire to a standard electrical connection, *M*, of dry battery, the other wire being grounded to the case. When the minimum allowable pressure has been applied, one of the remaining screws makes contact with a spring, *N*, mounted on a fiber block, *O*, lighting a white electric lamp, *P*. When the maximum allowable pressure has been reached, the other screw comes in contact with a similar spring, *Q*, lighting a red electric lamp, *R*. Both lamps may be observed by the operator through the holes in the cover, *S*. A coiled spring, *T*, adjusted by the screw, *U*, returns the operating lever to its initial position when the pressure is released.

The instrument is calibrated by placing a static load, including the weight of the briquette mold, etc., upon the platform, equivalent to the minimum pressure it is desired to register. The adjusting screw over the spring connected to the white lamp is then turned until contact is just made. An additional load, making the total equivalent to the maximum allowed, is then placed upon the platform and the screw over the spring connected with the red lamp is similarly adjusted.

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[1] The original design of this apparatus was prepared by E. B. Smith, formerly engineer of tests, Bureau of Public Roads.

This device has been in operation in the laboratories of the Bureau of Public Roads for several months and has proved very satisfactory. It should be possible to regulate the applied pressure by means of this device to any specified value plus or minus two or three pounds. In other words, such tests as the bureau has made would indicate that, by the use of the instrument, it is possible to mold briquettes conforming to the new standard specification in which the minimum pressure is specified at 15 pounds and the maximum pressure at 20 pounds.

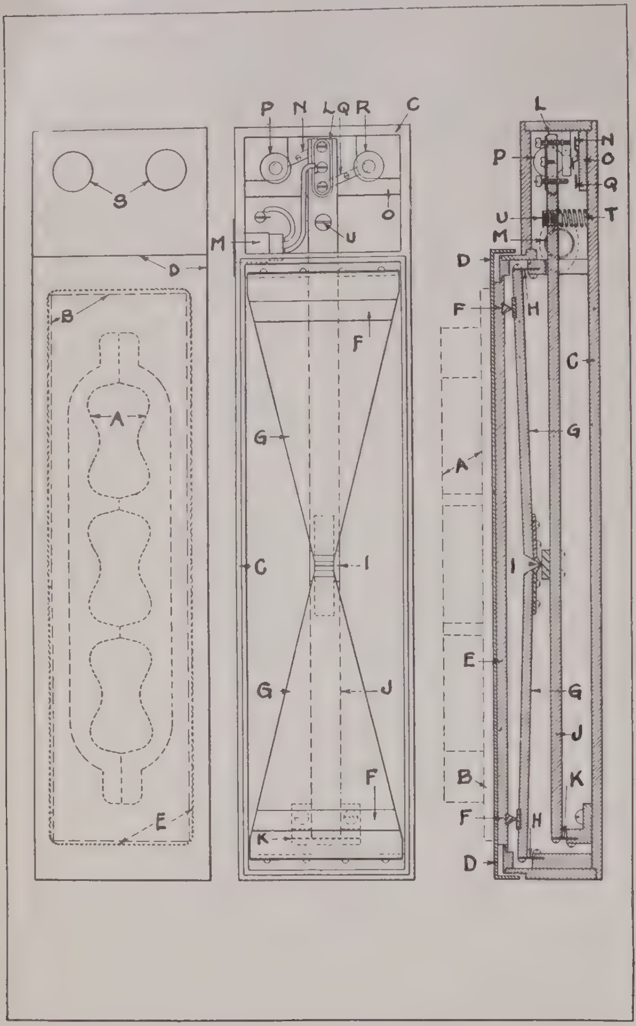


Fig. 1.—Detailed drawing of pressure registering apparatus

Effect of Varying Pressure

To determine the variation in strength resulting from molding briquettes at different applied pressures, a series of tests was recently conducted, using several different pressures. Two series of test specimens were made, with molding pressures and number of applications to each briquette face as follows:

Pressure, pounds—	Number of applications per briquette face
15-20	12
20-25	12
25-30	12
30-35	12
15-20	18
20-25	18
25-30	18
30-35	18

Tests were made at the age of 7 and 28 days. The two series were then repeated with a second brand of cement and tests made at the age of 7 days. Each average is the result of 12 breaks. The average results of these tests are shown in Table 1.

Table 1.—Effect of pressure and number of applications on average tensile strength of cement

Applied pressure, pounds—	Number of thumbings per briquette face	Tensile strength—pounds per square inch Cement A 7 days	Cement A 28 days	Cement B 7 days
15-20	12	245	365	280
20-25	12	250	370	285
25-30	12	260	370	290
30-45	12	260	370	290
15-20	18	260	370	285
20-25	18	260	370	300
25-30	18	265	390	290
30-35	18	270	385	300

Considering the several lots of 12 specimens each, it will be observed that the average tensile strength increases in general with increase in the applied pressure and with the number of applications of pressure. This would, of course, be expected. It should be noted, however, that the increase in strength is not quite so large as has commonly been supposed. For instance, tests at 7 days, using 12 applications with a 15 to 20 pound pressure, gave in the case of the first cement an average of 245 pounds per square inch, whereas a pressure of 30 to 35 pounds gave an average of 260 pounds per square inch, or an increase of 15 pounds. The corresponding variation in strength at 28 days was only 5 pounds, the 15 to 20 pound pressure giving an average of 365 pounds and the 30 to 35 pound pressure an average of 370 pounds. Likewise, increasing the number of applications of pressure from 12 to 18 gave an increase in strength of approximately 10 pounds per square inch for both periods. Similar variations may be noted in the case of the second cement. In general it was found that increasing the pressure from about 15 to 30 pounds resulted in an increase of strength of from 10 to 15 pounds, the greater divergence being at 7 days, whereas an increase in the number of thumbings for each briquette face from 12 to 18, resulted in an average increase of strength of about the same amount.

Table 2.—Deviation of individual test results from the average values

Applied pressure lbs.	Number of thumbings per briquette face	Cement A — Deviation from average tensile strength — 7 days Mean Per cent	7 days Maximum Per cent	28 days Mean Per cent	28 days Maximum Per cent	Cement B 7 days Mean Per cent	7 days Maximum Per cent
15-20	12	6.8	14.3	8.7	16.4	4.4	8.9
20-25	12	4.7	10.0	5.4	17.8	4.8	12.3
25-30	12	5.2	15.4	6.0	14.9	7.1	12.1
30-35	12	5.4	9.6	6.0	16.2	4.5	8.6
15-20	18	4.5	13.5	5.9	13.5	5.5	14.0
20-25	18	4.8	15.4	4.9	13.5	3.9	6.7
25-30	18	5.8	13.2	4.4	11.5	4.4	6.9
30-35	18	5.1	14.8	6.2	19.5	3.8	8.3

In Table 2 are shown the mean as well as the maximum deviations of individual breaks from the average of 12. It will be noted that in so far as concordance of results is concerned, there is little to choose between the various pressures tried. The same comment applies to the tests made with 12 applications of pressure as compared with those made with 18 applications. It will be noted that in many cases the maximum deviation from the average exceeded the 15 per cent allowed by the specification in routine testing.

Detailed working drawings of the instrument described in this paper have been prepared and will be furnished upon request.

Reinforced Concrete and the Building Codes

Few Engineers Realize That They May Use Reinforced Concrete Bearing Walls in Many Cities, Since They Are Confused by Lack of Agreement in Codes—Code Survey Shows Conditions That Lead to High Costs Because of Stringent Requirements, Rejection of Plans, Use of Uncommon Materials, and Other Evils.

How well does the engineer or contractor know the requirements of the different building codes of the cities in which his practice is to be found? Does he know that a design that would be feasible in one metropolis would prove impossible in another? Does the contractor know what sort of specifications he will have to live up to when negotiating for a job in a new city? Will his usual brand of cement meet the requirements of the building commissioner in that new city? It is the function of this article to cast a little light on the situation and suggest the need for a unification and standardization of codes, in order that the building public may get the most out of the construction dollar. —The Editors.

One economical and efficient type of building construction, exterior bearing walls of reinforced concrete, is quite commonly used on the Pacific Coast, and to a smaller extent in the South, yet this type of structure is but seldom found in the eastern and mid-western sections of the country, aside from buildings of the industrial type. Because of the failure of building officials to make specific provisions for this type of construction in their codes, the builder must utilize other systems, thus levying extra cost on the building public. In many cases a code will contain the inadequate and unfair provision that

> "reinforced concrete may be used in exterior and interior bearing walls; to a thickness not less than two-thirds the thickness specified elsewhere in this code for brick walls, but in no case less than 8 inches,"

but such a provision is practically meaningless in application and gets nowhere. Instead of making specific provisions for wall thicknesses it expresses the minimum thickness in terms of a material whose properties are entirely different. Or if such construction is permitted by code, the use of it might be made almost prohibitive by means of requirements that are excessive, especially since there is a lack of agreement among building officials as to just what the requirements should be.

Codes Poorly Written

But the case of exterior bearing walls is hardly different from the case of any type of concrete construction. Concrete is in its infancy. The concrete age is but commencing. It is therefore not surprising that the codes of today are but poorly devised to afford real opportunity for the concretor to take advantage of all the possibilities of his material. Codes have grown through isolated work by men whose ideas seldom coincided with those of their neighbors. Because of the shortage of general knowledge of the material, concrete was hedged about with precautionary safety factors that actually prove to be excessive, and in many cases which were the result of arbitrary selection rather than of scientific determination. Here and there are codes devised by leading expert concretors, but even here discrepancies are often to be found. For the most part these codes were written while certain theories were still under debate at the meetings of the technical societies. Other codes contain provisions adopting the recommendations of such bodies as the American Society for Testing Materials and the American Society of Civil Engineers, or of the joint committee. Thus the codes are automatically revised, as concerns these provisions, whenever the society changes its standard specifications. However, the legality of this form of adoption by reference is open to question in many states, due to state laws or court decisions.

Code revision, however, has like code formation, followed no particular rule. In most cities a code is revised by ordinance whenever the legislative body or administrative body decides that revision is needed. Thus a new word, paragraph, or section is grafted upon the main stem of the code without due thought to material otherwise contained therein. The result has been, and is, confusion.

Study of 56 Codes

A study of the codes of 56 cities, one state, and three national organizations shows a number of interesting points concerning the specified working stresses for plain and reinforced concrete and for the cement to be used therein. This material, tabulated on the following two pages, is well worth study.

Reference to the tabulation of the specifications, for instance, shows that direct compression on columns without spiral reinforcement ranges from 400 to 650 pounds per square inch, and from 20 per cent of the strength at 28 days to 29 per cent of that strength. One city allows 25 tons per square foot. Practically all of these specifications, however, are based upon a concrete that will reach a strength of 2000 pounds per square inch at 28 days. The last column of the table indicates, however, that some codes make due allowance for the use of stronger concrete.

WORKING STRESSES FOR PLAIN AND REINFORCED CONCRETE SPECIFIED IN BUILDING CODES

CODE AND DATE OF PUBLICATION	DIRECT BEARING	DIRECT COMPRESSION ON COLUMNS.			COMPRESSION IN EXTREME FIBER		SHEAR			BOND		REINFORCING STEEL						CEMENT TESTS					REMARKS
		WITHOUT SPIRAL REINF.	WITH SPIRAL REINF.				DIAGONAL TENSION ON BEAMS & SLABS					BILLET STEEL						NEAT CEMENT			1:3 SAND MORTAR		
		ON CONCRETE ALONE	ON CONCRETE ALONE	ADDITIONAL CREDIT GIVEN FOR SPIRALS	ORDINARY CASE	UNDERSIDE OF BEAMS OVER SUPPORT	WITHOUT WEB REINFORCEMENT	WITH FULL WEB REINFORCEMENT	PUNCHING SHEAR	PLAIN BARS	DEFORMED BARS	STRUCTURAL GRADE	INTERMEDIATE GRADE	HARD GRADE	RAIL STEEL	COLD DRAWN WIRE	SHEAR IN WEB REINFORCEMENT	24 HOURS	7 DAYS	28 DAYS	7 DAYS	28 DAYS	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
JOINT COMMITTEE 1924	25%	20%	Variable depending on percentage of vertical and spiral steel.		40%	45%	2 to 3%	6 to 12%	—	4%	5%	16000	18000	18000	18000	18000	—	A.	S	T	M		Column (3) is computed on the entire net area of concrete, no deduction being made for fireproofing. Percentages are based on ultimate strength of concrete.
AMERICAN CONC. INST. 1920	25%	25%	25%	Yes	37.5%	41%	2½%	6 to 12%	6 to 10%	4%	5%	16000	16000	18000	—	—	—	—	—	—	—	—	Percentages are based on ultimate strength of concrete.
NATIONAL BOARD OF FIRE UNDERWRITERS-1922	500	500	750	NO	650	750	40	120	—	80	100	16000	16000	16000	16000	16000	—	A.	S	T.	M.		Based on 1:2:4 concrete testing 2000 # Stress increased 20% for 1:1½:3 mix.
AKRON - 1911	600	600	—	—	700	—	—	65	—	—	—	16000	16000	16000	16000	16000	10000	A.	S.	T.	M		
ATLANTA - 1924	600	600	900	NO	750	—	30	150	120	80	100	16000	18000	—	—	—	12000	See city specifications					Based on 1:2:4 concrete. Higher strengths for richer mixes.
BOSTON - 1924	35%	22.5%	35%	NO	32.5%	37.5%	2%	6%	6%	4%	5%	16000 18000	16000 18000	16000 18000	16000 18000	20000 22500	—	A.	S	T.	M.		(13)-(17) Lesser values for beams; the greater one for slabs. Percentages based upon ultimate strength. 1:3 - 3,300; 1:4½ - 2,800; 1:6 - 2,200 #/□".
BRIDGEPORT - 1915	450	450	—	—	600	—	75	—	—	75	—	14000	16000	—	—	—	10000	200	550	650	175	300	Based on concrete testing 2000 #
BUFFALO - 1924	450	450	700	Yes	750	850	40	120	150	80	120	16000	16000	18000	—	—	—	—	—	—	—	—	For 1:2:4 mix, testing 2000 # Higher strengths for richer mixes.
BUTTE - 1917	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No provisions
CAMBRIDGE - 1914	30 tons	25 tons	—	—	500	—	60	—	—	60	—	16000	—	—	—	—	—	A	S.	T.	M		(6) is 600 # if richer mix than 1:5 parts of graded aggregate is used
CAMDEN - 1918	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	120	300	—	—	—	No unit stresses given in code.
CHICAGO - 1924	400	400	500	Yes	700	—	40	—	—	70	100	⅓ elastic limit or 18000			—	—	12000	200	500	600	175	240	Based on 2000 # concrete Concrete stresses are based on percentage of ultimate strength
CHICAGO VIADUCT ORDINANCE - 1917	450	450	500	Yes	750	—	40	120	120	80	120	16000	16000	18000	—	—	—	175	500	600	200	275	Based on 1:2:4 concrete Other mixtures are proportional
CINCINNATI - 1924	200	600	600	Yes	700	—	65	—	—	—	—	16000	16000	20000	—	—	—	—	—	—	—	—	Higher stresses allowed for richer mixtures
CLEVELAND - 1919	—	600	850	—	750	—	40	120	120	90	100	16000	16000	16000	16000	16000	10000	—	—	—	200	300	Based on 2000 # concrete. No provision for stronger concrete
COLUMBUS - 1913	200	500	700	—	700	—	50	120	—	70	100	—	16000	18000	—	—	12000	175	500	600	175	275	(3) is for column with 4 vertical bars. May be 600 # in columns with 8 bars. All concrete stresses may be increased 15% in work 2 years old. Based on 2000 #
DAYTON - 1917	500	500	600-850	No	650	750	40	120	120	80	100	16000	16000	16000	—	—	—	—	—	—	—	—	(4) is variable, depending on percentage of spiral steel.
DETROIT - 1924	450	550	—	Yes	650	—	40	130	130	80	100	16000	18000	20000	—	—	—	200	500	600	175	250	Stresses higher for richer mixtures
DULUTH - 1920	500	600	750	Yes	650	—	50	120	120	75	75	16000	18000	18000	—	—	10000	200	500	600	175	250	
FORT WORTH - 1919	15 tons	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A.	S.	T.	M.		Concrete must test 2000 #. Unit stresses not given. Design must follow good engineering practice.
HARTFORD - 1921	500	500	650-850	No	800	—	50	150	—	80	120	—	16000	18000	—	20000	10000	—	—	—	200	300	Based on 2,200 # concrete.
INDIANAPOLIS - 1925	25%	25%	Variable	Yes	37.5%	—	40-50-60	—	—	80	100	18000	20000	20000	20000	—	12000	175	500	600	200	275	1:2:4 concrete assumed as testing 2000 #; 1:1½:3 concrete, 2400 #; 1:1:2 concrete, 2900 #
JOPLIN - 1917	500	500	725	NO	650	750	40	150	—	80	80	¼ elastic limit			—	20000	—	120	300	—	—	—	(3) is increased 20% if 1:1½:3 concrete is used.
KNOXVILLE - 1915	400	400	500	Yes	700	—	40	—	—	70	100	⅓ elastic limit	18000	18000	—	—	12000	200	500	600	175	240	Based on 2,000 # concrete. Proportionately higher stresses for higher ultimate strength.
LAWRENCE MASS. - 1914	450	450	650	NO	650	750	40	120	—	80	—	16000	16000	16000	—	—	—	—	—	—	—	—	Based on 2000 # concrete. Higher stresses allowed in direct proportion to ultimate strength.
LOS ANGELES - 1923	—	550	800	NO	650	750	40	120	120	80	120	16000	16000	16000	—	—	—	200	500	—	200	—	Based on 1:2½:3½ concrete.
LOUISVILLE - 1909	650	450	650	NO	650	—	50	—	—	—	—	16000	16000	16000	—	—	—	—	—	—	—	—	Based on concrete testing 2000 #
MEMPHIS - 1912	29%	29%	35½%	Yes	33⅓%	—	2½%	—	5%	3⅓%	6⅔%	16000	16000	20000	—	20000	—	300	500	600	200	275	1:2½:5 concrete assumed as testing 1950 #. 1:2:4 concrete, 2250 #; 1:1½:3 concrete, 2550 #; 1:1:2 concrete, 3000 # (15) is for deformed bars. Plain bars are 16000
MILWAUKEE - 1922	400	500	800	NO	700	—	40	120	—	—	—	16000	16000	18000	—	—	—	175	500	600	200	275	Based on 1:2:4 concrete
MINNEAPOLIS - 1920	500	650	800	Yes	650	—	50	120	—	75	100	16000	18000	18000	—	18000	—	175	500	600	200	275	Based on 2000 # concrete.
NASHVILLE - 1917	500	450	650	NO	650	750	40	120	—	80	100	16000	16000	16000	—	—	—	A.	S.	T.	M.		Stresses in 1:1½:3 concrete may be increased 20%
NEWARK - 1924	500	500	500	Yes	650	750	40	120	—	80	100	18000	18000	18000	—	20000	—	175	500	600	—	—	Based on 1:2:4 concrete testing 2000 # Higher strengths for richer mixes.
NEW HAVEN - 1920	500	500	725	NO	650	750	40	120	120	80	100	16000	16000	16000	—	—	—	A.	S.	T M	180	—	Based on 1:6 concrete testing 2000 # Higher strengths for richer mixtures
NEW ORLEANS - 1913	500	400	—	—	650	—	50	—	—	50	50	0.4 e.l.	16000	16000	—	—	10000	A	S	C.	E.		Based on 2000 # concrete. No provision for stronger mixture.

WORKING STRESSES FOR PLAIN AND REINFORCED CONCRETE SPECIFIED IN BUILDING CODES

CODE AND DATE OF PUBLICATION	DIRECT BEARING	DIRECT COMPRESSION ON COLUMNS.			COMPRESSION IN EXTREME FIBER.		SHEAR			BOND		REINFORCING STEEL						CEMENT TESTS					REMARKS.
		WITHOUT SPIRAL REINF.	WITH SPIRAL REINF.		ORDINARY CASE	UNDERSIDE OF BEAMS OVER SUPPORT	DIAGONAL TENSION ON BEAMS & SLABS		PUNCHING SHEAR	PLAIN BARS	DEFORMED BARS	BILLET STEEL			RAIL STEEL	COLD DRAWN WIRE	SHEAR IN WEB REINFORCEMENT	NEAT CEMENT			1:3 SAND MORTAR		
		ON CONCRETE ALONE	ON CONCRETE ALONE	ADDITIONAL CREDIT GIVEN FOR SPIRALS			WITHOUT WEB REINFORCEMENT	WITH FULL WEB REINFORCEMENT				STRUCTURAL GRADE	INTERMEDIATE GRADE	HARD GRADE				24 HOURS	7 DAYS	28 DAYS	7 DAYS	28 DAYS	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
JOINT COMMITTEE '924	25%	20%	Variable depending on percentage of vertical and spiral steel.		40%	45%	2 to 3%	6 to 12%	—	4%	5%	16000	18000	18000	18000	18000	—	A.	S.	T.	M		Column (3) is computed on the entire net area of concrete, no deduction being made for fireproofing. Percentages are based on ultimate strength of concrete.
NEWTON, MASS.-1920	500	500	—	NO	650	—	40	150	—	80	80	16000	16000	16000	—	—	—	A.	S	T.	M		
NEW YORK-1922	500	500	500	Yes	650	750	40	150	—	80	100	16000	16000	16000	16000	20000	—	A	S. T.	M	—	250	Based on 2000# concrete (3) and (4) may be increased 20% for 1:1$\frac{1}{2}$:3 concrete
NORFOLK-1918	500	22.5%	33%	No	32.5%	37.5%	2%	6%	6%	4%	5%	16000	16000	16000	—	—	—	175	500	—	—	—	1:2:4 concrete assumed as testing 2000# 1:1$\frac{1}{2}$:3 concrete, 2500#; 1:1:2 concrete 3000#
OAKLAND, CAL-1921	500	600	800	—	700	—	40	120	100	80	120	16000	16000	18000	—	—	—	—	—	—	—	—	Also adopted Chicago Flat Slab Ruling, as amendment to code.
OMAHA-1923	20%	25%	35%	Yes	—	—	2%	—	—	70	100	$\frac{1}{3}$ elastic limit		18000	—	—	12000	200	500	600	200	300	(11) is 70 lb. for plain, round or sq. bars of structural steel; 50 lb. for high carbon steel.
PHILADELPHIA-1921	500	500	750	No	650	750	40	120	—	80	100	16000	16000	16000	—	—	—	A	S T	M.	180	—	Based on 1:2:4 concrete testing 2000# Higher strengths for richer mixtures.
PITTSBURGH-1913	500	540	750	Yes	650	650	—	—	—	80	80	16000	16000	16000	—	—	—	175	500	600	200	275	Proportional increase of not more than 25% allowed for concrete testing more than 2000#.
PORTLAND, ORE 1924	450	450	800	No	650	750	40	120	120	80	100	16000	16000	16000	—	—	—	Shall conform to city standard					Based on 1:2:4 concrete. For 1:1$\frac{1}{2}$:3 mix, increase 10%. For 1:1:2 mix, increase 20%
PROVIDENCE-1918	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No unit stresses given. Design to be based on good engineering practice.
RICHMOND-1922	650	450	700	No	750	—	40	120	120	—	—	16000	20000	20000	—	—	—	A	S.	T	M		Based on 1:2:4 concrete
ROCHESTER-1919	650	450	650	No	650	750	60	—	—	80	150	—	16000	20000	—	—	—	A.	S.	T.	M.		Based on 2000# concrete. Proportional increase allowed for concrete testing over 2000#
ROCKFORD, ILL-1920	450	—	550	Yes	650	—	40	130	—	75	100	$\frac{1}{3}$ of elastic limit or 18000#			—	—	10000	200	500	600	—	—	Based on 2000# concrete. All concrete stresses on percentage basis, with assumed ultimate strength of 2000# to 3000#
SALT LAKE CITY, 1913	400	400	500	No	500	—	50	—	—	60	100	$\frac{1}{3}$ elastic limit		20000	—	—	10000	175	500	600	200	275	Based on 2000# concrete. Limits are 500 for (2), 700 for (4), 500 for (6) and 75 for (8)
SAN FRANCISCO-1921	450	450	700	No	650	750	—	120	120	80	100	16000	16000	16000	—	20000	—	175	500	600	200	275	Column (4) may be 35% of ultimate strength of concrete assumed as 2000, 2,500 and 3000 lb./□" for 1:2:4, 1:1$\frac{1}{2}$:3 and 1:1:2 mixtures, respectively
SEATTLE-1924	25%	22.5%	Variable-Similar to 1924 Joint Committee Report		37.5%	41%	40	120 to 240	120 to 200	4%	5%	16000	18000	20000	—	20000	—	A S T M Standard C9-21					Stresses are in per cent of ultimate strength of concrete, assumed as 2000, 2400 and 2900 lb/□" for 1:2:4, 1:1$\frac{1}{2}$:3 and 1:1:2 mixtures, respectively.
SPOKANE-1919	400	500	750	No	650	—	40	120	—	80	80	16000	16000	.6000	—	—	—	175	500	600	175	225	Stresses 25% higher for 1:1$\frac{1}{2}$:3 mix. Stresses 50% higher for 1:1:2 mix.
SPRINGFIELD, MASS. 1922	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	S	T.	M		No allowable stresses given. Apparently up to Building Commissioner to approve or reject plans submitted.
ST. LOUIS-1918	500	500	800	Yes	800	—	35	150	100	65	Actual test	—	16000	20000	—	—	—	A	S.	T	M		Based on concrete testing 2000#
ST. PAUL-1916	450	500	750	—	650	—	40	120	120	50	100	16000	18000	18000	—	—	—	175	500	600	200	275	Based on 1:2:4 concrete testing 2000#
SYRACUSE-1922	600	600	850	No	750	—	40	—	120	80	100	16000	18000	18000	—	16000	—	175	500	600	200	275	Based on 1:2:4 concrete testing 2000#. Richer mix allowed proportional increase based on actual test, but not to exceed 25%.
TACOMA-1919	22$\frac{1}{2}$%	22$\frac{1}{2}$%	35%	No	32$\frac{1}{2}$%	—	2%	5%	6%	4%	5%	—	16000	16000	—	20000	10000	A S	T.	M	200	300	Based on ultimate strength. 1:1:2 concrete assumed as testing 3000# 1:1$\frac{1}{2}$:3 concrete 2500# 1:2:4 concrete 2000#
TOLEDO-1915	350	—	—	—	500	—	50	—	—	50	50	16000	16000	16000	—	—	—	300	500	600	—	—	
TULSA-1915	500	—	650	No	500	—	75	—	—	50	—	16000	16000	16000	—	—	—	A.	S.	T.	M		
WASHINGTON, D.C.-1917	450	—	—	—	650	—	40	120	120	80	—	16000	16000	16000	—	—	—	225	450	550	175	225	(But see below, for Washington D.C.-Code adopted in 1925)
WICHITA-1917	20%	—	25%	Yes	35%	—	2%	—	—	70	100	$\frac{1}{3}$ elastic limit		18000	—	—	12000	200	500	600	175	240	Percentages based on ultimate strength. (11) is 50# for high carbon steel.
WIS. INDUSTRIAL COMMISSION-1921	400	500	800	No	700	—	40	—	—	80	80	16000	16000	16000	—	—	—	A.	S	T	M.		Based on 1:2:4 concrete, testing 2000# (4) is 900# for 1:1$\frac{1}{2}$:3.
WORCESTER-1917	—	22.5%	32.5%	No	32.5%	37.5%	2%	6%	6%	4%	6%	16000	16000	16000	—	—	—	300	500	600	—	—	Stresses based on ultimate strength
WASHINGTON, D.C. 1925	25%	22$\frac{1}{2}$%	Variable depending on percentage of vertical and spiral steel.		40%	45%	2%	6 to 12%	—	4%	5%	—	18000	—	—	18,000	—	A S T.M. Standard C-9-21					Percentages are based on ultimate strength of concrete.

With columns reinforced with a spiral reinforcing, the same codes show a variation between 500 to 900 pounds, or 25 per cent to 40 per cent, on the concrete core, while four codes make this stress a variable. Eighteen of these codes allow an extra credit for the spirals, two have provisions giving variable credit, 26 of the codes allow no additional credit, while 14 ignore the matter entirely. As wide a range of opinion is expressed in the column devoted to compression in extreme fibre.

Shearing stresses, when no web reinforcement is used, range from 30 to 75 pounds, or from 2 to 3 per cent. With full web reinforcement, some codes figure as low as 65 pounds and others as high as 240 pounds, or as low as 5 per cent and as high as 12 per cent. Punching shear ranges from 100 to 200 pounds or 2 per cent to 10 per cent.

Bond Stresses

There is also a wide variation for bond stresses in plain billet bars and deformed billet bars. The joint committee allows a 1 per cent credit on the use of a deformed bar, the stresses being 4 and 5 per cent, to which recommendation the American Concrete Institute concurs. Some cities allow the same stresses on both, while other cities allow credits of from 1 per cent to 3 1/3 per cent. Expressed in pounds, the credits run from zero to 40 pounds. The bond stress in plain bars is mostly 4 per cent, and in one case 3 1/3 per cent, when expressed as percentages, or from 50 to 90 pounds. Rail steel bars are permitted in but seven of these codes, and in the codes are allowed the same stresses as hard grade billet steel bars. Cold drawn wire is mentioned in 16 of the codes, and is allowed stresses ranging from 16,000 pounds to 22,500 pounds. Shear in web reinforcement, as allowed in 16 of the codes, is listed at 10,000 pounds in 9 codes and 12,000 pounds in the remaining seven.

The matter of cement tests, wherein there should probably be no variation, shows quite a lack of agreement. It is true that 19 of the codes have adopted the standards of the American Society for Testing Materials. One, however, has adopted the American Society of Civil Engineers' specifications, and that city is New Orleans. Two other codes merely refer to standard specifications of the city concerned, and set forward elsewhere in the ordinances of that city. Neat cement strengths at 24 hours otherwise range all the way from 120 to 300 pounds, 7-day strengths range from 300 to 550 pounds (the majority requiring 500 pounds), and 28-day strengths are set at 600 pounds, with one exception, where 650 pounds are required. When mixed into a 1:3 sand mortar, there is some difference in specifications. The lowest 7-day strength specified is 175 pounds (in 8 codes), while two codes require 180 pounds at that age, and 15 codes require a strength of 200 pounds. Three codes require a 28-day strength of 240 pounds, three call for 250 pounds, eleven require 275 pounds, and five call for 300 pounds. One code requires a 28-day strength of only 225 pounds. That latter city happens to be low in all its other requirements. This is the city of Spokane, in its code of 1919.

It is easy to see, from this survey, that there is a woeful lack of uniformity in code requirements, in spite of the fact that uniform materials are available and construction practice itself possesses real possibilities of standardization of strengths obtained from uniform materials. Since there is no need for lack of uniformity, and since lack of uniformity makes for waste, the conditions revealed herein indicate needed action toward unification.

Bearing Walls in Seattle

To get back to the matter of concrete bearing walls, the Seattle code which was adopted in 1924, makes definite provision for this type of construction. This code provides for what might be considered safe practice and the quoted portion is a good model for other codes where such a revision is to be made. The following provisions, extracted from the code, take care of the matter very well:

> Reinforced concrete bearing walls shall have a thickness of at least one twenty-fifth of the unsupported height, provided, however, that approved buttresses, built-in columns, or piers, may be used in lieu of greater thicknesses.
>
> The working compressive stress in such walls shall not exceed $f'_c/16$ when the wall is 25 times the thickness in height, increasing proportionally to $f'_c/8$ when the wall is 15 times the thickness, or less, in height. (The symbol f'_c denotes the crushing strength of the concrete at the age of 28 days.) Such walls shall be reinforced with at least one-sixth of 1 per cent of steel in each direction, vertical and horizontal. Walls 8 inches or more in thickness shall have the steel equally distributed on each face of the wall.
>
> The vertical steel may be relied upon to carry load when tied and arranged as in reinforced concrete columns.
>
> No reinforced concrete bearing wall shall have the bars further apart in each direction than 18 inches, regardless of whether the steel is disposed in one or two layers, nor shall less than the equivalent of ⅜-inch round bars be so used.
>
> As used in this section, the lateral support for such walls shall consist of a reinforced concrete floor when the framing is on one side of the wall only, or of a non-fireproof floor, framing on both sides of the wall; provided that for residences wood frame construction properly tied may be used as a lateral support.
>
> Eccentric loads and wind stresses shall be fully provided for.
>
> Subject to the other requirements of this section, reinforced concrete bearing walls shall have a thickness at least equal to that specified in the following table:

	Minimum Wall Thickness, in Inches, in Story Indicated										
Number of Stories	Basement	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1	6	6	—	—	—	—	—	—	—	—	—
2	7	6	6	—	—	—	—				
3	8	7	7	6	—	—	—		—	—	—
4	8	8	7	7	6	—	—	—	—	—	—
5	9	8	8	7	7	6	—	—	—	—	—
6	9	9	8	8	7	7	6	—	—	—	—
7	10	9	9	8	8	7	7	6		—	—
8	10	10	9	9	8	8	7	7	6		—
9	12	10	10	9	9	8	8	7	7	6	
10	12	12	10	10	9	9	8	8	7	7	6

> Exterior bearing walls of non-fireproof buildings may be of reinforced concrete, subject to the provisions of this section, when increased 50 per cent in thickness over the above table.
>
> In such walls the amount of reinforcement shall be at least one-tenth of 1 per cent in each direction, horizontal and vertical, the steel being equally distributed on each face of the wall, with a maximum bar spacing of 24 inches.
>
> Stairway and elevator enclosures in all classes of buildings may be built of reinforced concrete, when the wall thicknesses are in accordance with the above table, and the said walls are reinforced in accordance with the provisions of this section.

It is said that this type of construction, when coated on the exterior with portland cement stucco, produces a fireproof exterior wall at a cost lower than may be obtained with any other material. In the interest of economy the above extract from the Seattle Building Code might therefore be studied with the view of incorporating similar provisions wherever building codes are undergoing revision. The table of wall thicknesses is indeed unique, since such a table occurs in no other codes now in use as far as is known.

But not until the codes uniformly require reinforced concrete floors and roofs, and permit the economical construction of the same, will the day of the truly fireproof building be at hand. In that day the wooden home will be built on the principle of larger fireproof buildings. It is to this point that code revisions are bound to lead, and the matter of this development is the direct responsibility of the experienced contractor, engineer and architect whose work has given them a real insight on the economies of good reinforced concrete construction. The great waste of fire will only be reduced to normal and minimum proportions when all buildings, dwelling houses included, are guarded against exterior and interior fire hazards, by means of fireproof construction. Such hazards as come from today's heating and cooking arrangements, and from the other industrial and domestic methods that lead to fire, will be further minimized by improvements in equipment.

Suggestions on Revision

The great fight for the present, however, is that for the unification and correct revision of building codes. This work, as done by those who know how, is approached upon the basic need for safe and fireproof construction at the lowest possible cost. All available data is gathered as to the performance of types of construction and as to safe construction practice. The facts are then laid before the public through the medium of the daily press, while the code-making body of the community is approached. This work is generally taken over by a committee representing the local construction industry. The proposed new code is drawn up by this committee, and is "sold" not only to the public but to the council or other body having local legislative powers. The local administrative officials are also "sold," since their approval is usually required and their support is of great value. Eventually the proposed code is passed, but the originators must be on their guard to prevent changes that will endanger the workings of the code. Few codes are successfully changed until a specialist is hired by the city to write an entirely new code, discarding completely all provisions previously in force. The new code of Pittsburgh is an outstanding example of the work of a building code specialist.

Standard codes are being proposed. The outstanding one at the present time is that now being considered on the West Coast. It will not only afford a practical model for codes elsewhere, but may even be adopted in its final form without further revision, since it is one of the few scientifically constructed codes in existence. This code will be further described in a later issue.

Get Ready for Winter Work, Says Building Congress

The New York Building Congress is circularizing their mailing list to carry on the tendency toward winter construction. Cold weather work is claimed to be less costly than summer work even though the direct cost of heating and other extra precautions apparently add to the cost. Offsetting factors are said to include the elimination of labor bonuses, reduction of labor turnover, spread in overhead expense, seasonal discounts on materials, seasonal freight rates, saving of interest and taxes on idle investments, and earlier return on investment. The result, it is claimed, is a material reduction in the cost of the work, especially on projects that will cost more than $100,000.

Huron Portland Cement Company and Wyandotte Portland Cement Company Organize Service Bureau

John W. Kennedy has been appointed engineer of the Huron Portland Cement Company and the Wyandotte Portland Cement Company's new service bureau, with headquarters at Detroit, Michigan. In inaugurating their service bureau the companies will supplement their present activities with a technical service to engineers, architects, contractors and others who desire to utilize concrete and its materials to best advantage.

It is possible, by careful application of Abram's water-cement ratio law, and the new developments in concrete design and practice, to utilize a "high grade" portland cement as produced by these companies conforming to the standard specifications for practically all service conditions. The Huron and Wyandotte companies will carry this idea to the consumer through the activities of their service bureau.

Mr. Kennedy is well known in Michigan engineering circles, and has the training and experience that qualify him to carry on the work. He graduated from the University of Michigan in 1921, and the following year received a master's degree in engineering. After serving for a year as instructor in the college of engineering, he joined the Michigan State Highway Department in the capacity of assistant director and later, director of its testing laboratory. More recently Mr. Kennedy has been studying the newest developments in concrete practice under Professor Abrams at the Structural Materials Research Laboratory, Lewis Institute, Chicago.

It is important in this age of modern development in the construction industries, that materials be used to the best and most economical advantage. With his training, Mr. Kennedy should make a valuable addition to the service staff of the Huron and Wyandotte companies, as they are in a position to render important service to those who desire to obtain the best possible in concrete under all conditions of service and exposure.

To Disclose Secrets of French Bridge Builders

The design and construction methods that permit French engineers to construct fixed arch reinforced concrete bridges with spans far wider than seen in this country, have been studied by J. F. Brett, Montreal structural engineer. Mr. Brett is to disclose these unusual methods to American engineers in a paper on "The Reduction of Flexural Stresses in Fixed Reinforced Concrete Arches," to be read before the Western Society of Engineers, Chicago, on Monday evening, September 13.

Mr. Brett will describe the methods devised by French engineers to eliminate certain flexural stresses in fixed arches, thus leaving a greater portion of the allowable working stresses available to resist stresses due to dead load and live load. These methods have made possible the design and construction, in France, of reinforced concrete arches of much longer span than in the United States.

In our next issue we will present a detailed synopsis of this important paper, wherein the principles involved will be explained in a simple and easily understood manner.

Milwaukee now permits the use of 8-inch concrete block in the construction of small garages. This should result in the sale of a good quantity of such units in that city.

Experimenting on a Large, Heavy Duty Terrazzo Floor

How the Fruin-Colnon Co., General Contractors, Determined Upon the Best Specifications for Terrazzo Work When Erecting Building for Printers in Mid-Western City—The Tests That Demonstrated the Best Method for Doing the Work

The test load, on the three-wheeled truck, being drawn over the slab

The recently completed Woodward-Tiernan printing plant in St. Louis, built by the Fruin-Colnon Company, general contractors, was the scene of some important and interesting tests that were instituted to find the best type of terrazzo floor covering for heavy duty industrial floors, and with the primary idea to find the best type of floor for that plant itself. This one-story and basement printers' building contains 220,000 square feet, and the floor must stand up under the heaviest type of trucking, and withstand the heavy loads of such occupancy, serious vibration, and spillage of hot type metal.

Since this was but the second terrazzo floor to be installed in an industrial plant in the United States, and since the floor was to cover so vast an area, rule-of-thumb methods could not be followed with any assurance of success. The contractor therefore decided to institute some comparative tests with two types of finish, and three types of material, and follow the most successful of the six types of finish in laying the entire floor after the experimental strips had demonstrated their merits.

Three types of aggregates were tested in the first test section—traprock, gravel, and granite. Slab No. 1 contained Missouri Red Granite, No. 2 contained Meramec River Gravel and Sand, No. 3 contained Traprock (the standard floor mixture graded ¼-inch and under, and slab No. 4 was made with a special mixture of traprock graded to ¾-inch and under. The materials were purchased on a fineness-modulus basis. The fineness-modulus of the regular traprock averaged 4.351, conforming to the American Concrete Institute Specifications for heavy duty floor topping. The special grading of traprock was made of a mixture of three parts coarse traprock and one part standard mixture. The coarse traprock was graded as follows:

Sieve	Percent Ret.
⅝-in.	5.05
½-in.	28.80
⅜-in.	63.88
Pass ⅜-in.	2.27
	100.00

The fineness modulus of this material was 5.19. This mixture was used in one test slab in a 1:2½ mix.

The Missouri Granite was graded as follows:

Sieve	Percent Ret.
⅝-in.	0.0
½-in.	0.0
⅜-in.	0.0
¼-in.	64.25
⅛-in.	31.18
Pass ⅛-in.	4.57
	100.00

This gave a fineness modulus of 5.596 when calculated from the standard sieve series.

The Meramec gravel was graded as follows:

Sieve	Percent Ret.
⅝-in.	0.0
½-in.	0.0
⅜-in.	6.05
¼-in.	60.60
Pass ¼-in.	33.35
	100.00

The fineness modulus of this gravel would figure out to be 5.66. For the first experimental slabs the 1:2½ mix was prepared by hand in a wooden box and applied after the green floor had been roughened with picks, the laitance removed with wire brooms, and the floor cured with a layer of wet sand. After the base had cured sufficiently the surface was swept clean and washed with clean water. The surface was then covered with a dry grout of one part cement and one part sand, and this was worked into the interstices of the rough concrete with stiff wire brooms. Care was taken to remove excess water in the low spots before proceeding with the terrazzo work. Round pipe, one inch in diameter, were then set to the finished floor grade to act as screed guides. Later these proved unstable and angle irons were adopted for the balance of the work.

Finishing the Slab

The different floor surfaces, after screeding, were floated with a wooden float and finished with a steel trowel. The finished surface was kept moist for a day and then covered with sand and wet down at regular intervals. This floor topping averaged more than one inch in thickness. After the topping had cured, grinding machines equipped with carborundum bricks were used to bring the surface to the desired finish and to expose the aggregate. A small amount of fine river sand and water were used to expedite this work. Carborundum brick No. 20 were found to be the most practical for this purpose, each machine grinding approximately 700 square feet of floor per 8-hour day.

After the floor had been properly ground, the grinding machines were used to rub carborundum grit into the surface to harden the floor and to fill air holes and pits. A mixture of 1 part cement to 2 parts No. 80 carborundum grit was used for this purpose. After applying the hardener the surface was cleaned by washing with water, then two applications of magnesium fluosilicate were applied with a soft dust broom. The first application called for ½ pound of the hardener dissolved in one gallon of water, while the second application called for 2½ pounds in the gallon. The first application was allowed to penetrate and the floor surface to become dry before making the second application. One gallon of the solution was found to cover about 100 square feet of surface. To bring out the color of the stone aggregate and to prevent the possibility of dusting, the surface was then treated with a light application of kettle-boiled linseed oil, applied with cotton waste.

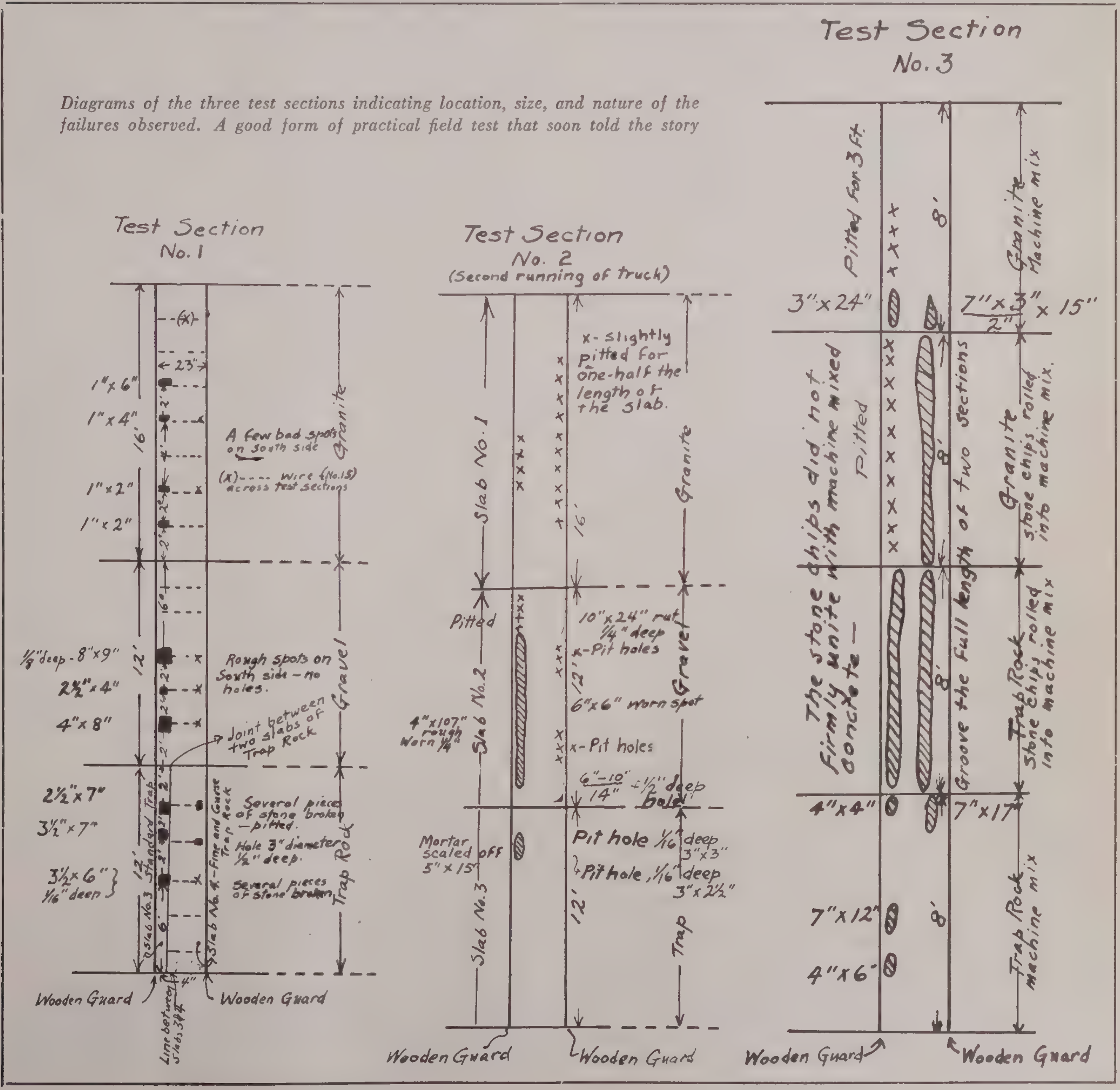
First Wear Tests

The first wear test was made to determine the best type of aggregates among those listed above. A three-wheel truck loaded with 51 sacks (2¾ tons) of sand was moved forward and backward over the surface within fixed lines, in order to concentrate the wheel loads on the surface area under test. This test was carried on for 100 hours. The truck wheels were of steel, six inches in diameter and four inches wide. On the second day strands of wire were placed across the slab in order to obtain impact as the wires were crossed by the truck. Five strands were placed across the granite section, six across the gravel section, and five across the traprock section. Each test showed a failure in the wearing surface, and the failures were rated in the following order: gravel, small traprock, large traprock, and granite, with very little difference in the wear between the granite and the traprock in section 1.

Another similar test section was then run, omitting the impact feature, and the failures were rated in the following order: gravel, granite, traprock.

Method Tests

When these tests were completed another series of tests was run in order to determine the relative merits of topping made by drifting stone of a uniform size over the floor mixture and imbedding them by rolling, with the alternate method of placing a machine mixed topping and



Diagrams of the three test sections indicating location, size, and nature of the failures observed. A good form of practical field test that soon told the story

Test Section No. 1
1"x6"
1"x4"
1"x2"
1"x2"
16'
23"
(x)
A few bad spots on South side
(x)---- Wire (No.15) across test sections
Granite
⅛"deep-8"x9"
2½"x4"
4"x8"
12'
Rough spots on South side - no holes.
Joint between two slabs of Trap Rock
Gravel
2½"x7"
3½"x7"
3½x6" 1/16" deep
12'
Slab No.3 Standard Trap
Slab No.4 - Fine and Coarse Trap Rock
Several pieces of stone broken - pitted.
Hole 3" diameter ½" deep.
Several pieces of stone broken
Trap Rock
Wooden Guard
Line between slabs 3&4
4"
Wooden Guard
Test Section No. 2 (Second running of truck)
x - slightly pitted for one-half the length of the slab.
Slab No.1
16'
Granite
Pitted
10"x24" rut ¼" deep
x-Pit holes
Slab No.2
12'
6"x6" worn spot
Gravel
4"x107" rough Worn ¼"
x-Pit holes
6"-10" 14" ±½" deep hole
Mortar scaled off 5"x15"
Pit hole 1/16 deep 3"x3"
Pit hole, 1/16 deep 3"x2½"
Slab No.3
12'
Trap
Wooden Guard
Wooden Guard
Test Section No. 3
Pitted for 3 ft.
8'
Granite Machine mix
3"x24"
7"x3"/2" x 15"
The stone chips did not firmly unite with machine mixed concrete -
Pitted
8'
Groove the full length of two sections
Granite stone chips rolled into machine mix.
8'
Trap Rock Stone chips rolled into machine mix
4"x4"
7"x17"
7"x12"
8'
4"x6"
Trap Rock machine mix
Wooden Guard
Wooden Guard

then exposing the aggregate by grinding to obtain the terrazzo finish. Four slabs were constructed, one of each method using the granite and one of each method using the traprock.

Type "A" topping, the first type mentioned in the above paragraph was laid using both granite and traprock. The traprock section mix was changed from the theoretical 1:½:2 proposed since that proportioning did not prove feasible on the first test section. Instead, a 1:1:2 mix was adopted in order to obtain sufficient mortar to embed the stone chips that were to be drifted over the surface after it had been leveled off with a screed. The chips were forced into the surface and embedded into the mortar by means of a water-weight roller. Four cubic feet of chips were made to cover 176 square feet of surface. After this the surface was finished with the steel trowel and the topping allowed to cure for seven days before grinding. The terrazzo effect was good.

Advantage was taken of the experience with the traprock sections in laying the granite section. The mix was so altered, in accordance with this experience, in order that an excess of fine material would be available to receive the terrazzo finish. The Type "A" granite section was laid with a 1:1:2 mix and granite chips were then drifted over the surface the same as in the above traprock section. The rest of the work was done in the same manner.

The Second Method

The Type "B" finish called for a different treatment. On the traprock section the slab was laid with a machine-mixed concrete corresponding to a dry mix of 1:¾:2½ mixture. The finishers were unable to bring sufficient mortar to the surface for a trowel finish with this proportion, so the mix was changed to the 1:1:2 for the north half of the slab. (This slab was laid before the Type "A" slabs mentioned above.) There was a decided improvement in the workability of the mix, yet a few honeycomb spots developed in the floating operation. These spots were filled with 1:1 mixture of the fine and coarse traprock mentioned in connection with the first test section.

The lack of sufficient mortar for surface finishing may be attributed to the small amount of concrete required per square yard for a ¾-inch topping. The experiment demonstrated that a floor topping mixture, to be workable, must carry an excess of fine aggregate or portland cement, or both, over the amount calculated as required to fill the voids in the aggregate. As a result of these observations it has been recommended that the following mix will provide the right workability and a satisfactory composition for finishing with the grinding machine:

1 part portland cement
1 part standard traprock mixture, ¼-inch and down
1½ parts traprock ⅜- to ⅝-inch.

The Type "B" granite section was then laid with a 1:1:2 mix of granite, the fine aggregate graded from ¼-inch down, and the coarse aggregate graded from ¼ to ½-inch. In each case the slab was then screeded, and afterward compacted with a roller.

Finishing the Surface

The surface was then swept with soft brooms to remove surplus cement and then lightly worked with the steel trowel. No attempt was made to remove trowel marks, since these would be removed by the machine, and one troweling was considered sufficient. A week later the surface was ground down with the grinding machine in order to expose the aggregate, and the holes then filled with the carborundum grout already described. The filler was then allowed to set for another seven days, and the second grinding operation performed to remove the grout and obtain the polish.

The second wheel load tests were then run in order to determine the best of the two materials and the best of the two methods. The wheel load developed excessive wear on the traprock and the granite sections of Type "A" construction. The stone chips parted from the concrete under concentrated loads, indicating an inherent weakness in this type of topping under abnormal wheel loads. Machine mixed concrete used as in Type "B," did not fail seriously under the wheel load test. The traprock appeared to be but a trifle better than the granite in the two Type "B" sections, so a traprock terrazzo, where the aggregate is exposed by means of grinding, was adopted as the standard floor finish for the building.

The final specifications adopted for that type of construction were as follows:

Floor Topping—Terrazzo Finish—Trap Rock Aggregate

1. The concrete contractor shall pour the floor slab and screed the concrete with a straightedge, bringing the surface of the concrete ¾ of an inch below the finished floor grade.

2. As soon as possible after the concrete slab is poured, the surface shall be thoroughly broomed to expose the coarse aggregate and remove the loose scaling, laitance or other foreign material, and allowed to cure.

3. Before applying the wearing surface mixture, the slab shall be washed and sprinkled with neat cement, the cement grout to be brushed over the surface with a broom.

4. A traprock wearing surface mixture, in the proportion of one (1) part cement to one and seven-tenths (1.7) parts stone, (Mix: 3 sacks cement to 5 cubic feet of coarse and fine traprock) ranging in size from ½-inch down to dust, the mixture to be put down reasonably dry. (Note: ¾-inch by ¾-inch angle irons, with the heel of the angle turned up, are recommended for screed guides.)

5. The wearing surface mixture, after being screeded, shall be compacted with water-weight rollers. (Two rollers are required, one light weight and the other heavy weight.) Rolling to be done in both directions and continued until water is brought to the surface. (The surface before rolling may be sprinkled with a dry mixture 1 part cement to 1½ parts traprock, in order to absorb surplus water so as to permit rolling earlier than would otherwise be possible. Atmospheric conditions should be taken into consideration.)

6. After rolling, the surface to be swept with soft brooms to remove the water and surplus cement which has been brought to the surface by the rollers. The surface shall then be lightly steel troweled, but no attempt made to remove all trowel marks as is the practice in trowel finished floors. (One troweling sufficient.)

7. About a week or more after the surface is troweled, it shall be ground down with an approved type of grinding machine, shod with No. 20 carborundum brick, to expose the coarse aggregate. The material removed in grinding to be washed off the surface.

8. Air holes, pits, etc., developed in the grinding process shall be filled with a thin grout composed of one (1) part portland cement, one (1) part No. 80 grain, powdered carborundum grit, spread over the surface and worked into the "pits" with a steel straightedge, to be followed with rubbing process with the grinding machine. Excess material shall be promptly removed after the grinding machine operation. Filler shall be allowed to set for seven (7) days.

9. The floor surface shall receive a final grinding to remove the film of grout and to give it a polish. It shall then be thoroughly washed and all surplus material removed.

(Concluded on page 49)

Water-Ratio Method of Designing Concrete Mixtures

An Outline of the Abrams Theory of Proportioning Written by the Author of the Theory—Water-Cement-Ratio and Fineness Modulus—Older Forms of Specifications—Reports from Other Laboratories That Confirm the Theory

By DUFF A. ABRAMS

The expression "fineness modulus method of proportioning concrete," frequently used to describe the writer's method of designing concrete mixtures, is somewhat of a misnomer. The basic principle of the method is the intimate relation between the quantity of mixing water (the "water-cement ratio") and the *strength and other properties of the concrete*, so long as the concrete is plastic and workable. The cement-water ratio is the ratio of the volume of mixing water to the volume of cement in the batch—conveniently measured in gallons per sack of cement.

The fineness modulus of the aggregate is an aid in determining the *most economical quantity and grading* of given aggregates, but is incidental to the main idea underlying the cement-water-ratio method; the true significance of this method has been somewhat obscured by some writers by too much emphasis on the fineness modulus.

Tests carried out by the writer* (later confirmed by a number of other investigators) showed the controlling influence of the water-cement ratio, regardless of mix, size or grading of aggregates, characteristics of the cement, consistency of concrete, age at test, etc., so long as the concrete is plastic and workable. It is assumed that only aggregates which are clean and of suitable strength and durability will be used.

An excess of mixing water results in concrete of low strength and inferior resistance to weather and other destructive agencies. Increasing the quantity of mixing water beyond that necessary to produce a workable mix serves to dilute the cement paste and produces a dispersion of the cement particles so that adhesion between cement particles and between cement and aggregate, is greatly weakened. The mere use of more cement accomplishes no useful purpose unless the water-ratio is thereby reduced.

Using average portland cement, the relation between compressive strength and water-ratio may be represented by:

$$S = \frac{14000}{7^{x}} \quad\ldots\ldots\ldots\ldots (1)$$

where S = *28-day compressive strength of concrete cured at a temperature of 65 to 75° F. and tested in 6 by 12-in. cylinders.*

x = *(an exponent) water-ratio; that is, ratio of volume of mixing water to volume of cement, (7½ U. S. gallons per 94-lb. sack of cement = water-ratio 1.00).*

The experimental basis of this law has been outlined in a number of papers presented before technical societies and published in this journal. Confirmation of the law is to be found in the references given at the end of this article. A water-ratio-strength relation of the same type has been found for lime mortars, gypsum, etc.

While compressive strength is not the only important requirement of concrete, it has been shown that flexural strength, resistance to wear and many other desirable properties are influenced in much the same way as the compressive strength by variations in water-cement ratio. Our unpublished tests show a close coordination between the 28-day compressive strength of concrete and its resistance to exposure in the field to sulfate soils and waters in Colorado and South Dakota. An important property of concrete is its resistance to weathering which is measured to a large extent by its permeability. Prof. M. O. Withey of the University of Wisconsin has shown that permeability is decreased with increased compressive strength and that maximum water-tightness is obtained over a narrow range of water-ratios.

Designing Concrete Mixtures

The aim of the water-cement-ratio method of designing concrete mixtures is more than the *proportioning of aggregates*—it furnishes a practicable method of securing a predetermined strength when the concrete is properly mixed, placed and cured.

The design of a concrete mix by the water-cement-ratio method consists of two steps:

(1) Fix the water-cement ratio which will produce the required strength (free water held by the aggregates must be included as mixing water in fixing this ratio).

(2) Determine by trial or calculation the proportions of cement, fine and coarse aggregates which can be most economically used to produce concrete of the required workability.

It should be emphasized that this method fully recognizes the importance of *workability;* in making concrete we must *pay for workability* in exactly the same way as we pay for strength or other properties. Workability may be measured by the "slump" or "flow."

Where the water-cement ratio is carefully controlled by accurate measurement of quantities of water, cement, and aggregate and corrections made for water carried by aggregate, we use Equation (1); however, in order to be somewhat conservative in cases where the water-cement-ratio is only indifferently controlled and rough methods of measuring aggregate, etc., are used, we recommend that design be based on a 28-day strength of

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*The laws on which the water-cement-ratio method is based were developed in the experimental studies of concrete carried out at Lewis Institute during the decade 1916-1926 by the Structural Materials Research Laboratory, through the cooperation of the Portland Cement Association and the Institute. This cooperative arrangement was terminated on June 30, 1926; however, the researches are being continued by the same staff in the new research laboratory of the Portland Cement Association, 33 West Grand Avenue, Chicago.

$$S = \frac{14000}{9^x} \quad \ldots\ldots\ldots\ldots (2)$$

which gives strengths about 500 lb. per sq. in. lower than Equation (1). On important work, the constants in Equation (1) should be more accurately determined by concrete tests covering a range of water-cement ratios and the cement and aggregate to be used.

This method permits the widest latitude in quantity, size and grading of aggregates. If the proportions of fine and coarse aggregate are determined by calculation, use is made of the fineness modulus, as noted below.

Water-Cement Ratio Specification

The practicability of this method has been shown by its use as the basis of a specification in the construction of the reinforced concrete building for the Portland Cement Association, Chicago. The quality of concrete was fixed by three simple requirements:

(1) *Mixing water* limited to 6 or 7½ gal. per sack of cement, depending on whether concrete of 2900 or 2000 lb. per sq. in. at 28 days was required,

(2) *Proportions* of cement and aggregate determined solely by the requirements of workability,

(3) *Aggregate*—quantity of coarse not less than fine and not more than twice fine.

The complete specification and a report on the tests made on this building are given in two papers by McMillan and Walker, one read before the last convention of the American Concrete Institute, and the other to be read at the 1926 meeting of the American Society of Civil Engineers, in October.

Older Specifications

The older specifications based on fixed proportions of cement, fine and coarse aggregates and rigid limitations on size and grading, frequently result in inferior and at the same time, more costly concrete. The difficulty here is due to a misapprehension as to the true nature of concrete, largely as a result to the entire neglect of the quantity of mixing water, which we now recognize as a most important factor in concrete.

The older type of specifications tend to increase the cost of concrete for two reasons:

(1) In general, more cement is used than would be necessary for a given strength, if proper limits were placed on the quantity of mixing water. (It was long considered axiomatic that the strength of concrete was a function of the *quantity of cement*, whereas we now know that it is a function of the water-cement ratio. Rich mixes give better concrete only due to the lowered water-cement ratio).

(2) Aggregates are required to conform to rigid limitations on size and grading in order that some arbitrary proportions might give the desired strength. As a result it is frequently necessary to transport aggregates long distances or to waste certain sizes, thus adding to the cost. By the water-cement-ratio method failure of aggregate to meet the old requirements for size and grading is no longer considered of prime importance, since usual variations can be largely compensated by changes in mix, without sacrificing the strength or quality of the concrete. Almost any two or more fine and coarse aggregates may be combined in such a manner as to give good results.

Fineness Modulus

As an aid in applying the water-cement ratio to the design of mixtures, especially where a large number of aggregates must be considered or where facilities are not at hand for making trial mixtures, the principles of combining aggregates on the basis of the fineness modulus are useful. Our tests have established for a wide range in materials the limiting values of the fineness modulus for proper workability.

The fineness modulus is a *quantitative measure* of the size and grading of aggregate based on the sieve analysis; it is graphically represented by the *area under the sieve analysis curve,* when percentages coarser than each sieve are platted as ordinates and the standard sieve sizes are platted to a logarithmic scale as abscissae.

The fineness modulus is useful in showing how different fine and coarse aggregates may be combined to best advantage and in indicating the quantity of mixing water required by aggregate of different size and grading, but it is not an essential feature of the water-cement-ratio method. Bulletin 1 of the Structural Materials Research Laboratory, gives further details of this method of calculation.

Verified by Others

The following reports from other laboratories verify the water-cement-ratio-strength relation for concrete:

"Wear and Compression Tests of Concrete," by R. B. Crepps; Proc. American Concrete Institute, v. 16, p. 114, 1920.

"Strength of Concrete, Its Relation to Cement, Aggregate and Water," by Talbot and Richart; Bulletin 137, University of Illinois Engineering Experiment Station, 1923.

"The Composition of Mortar in Concrete," by O. Graf; published by Springer (Berlin), 1923.

"Rational Proportioning of Concrete and Predetermination of the Compressive Strength in the Field," by O. Graf; Gesundheits-Ing., No. 26, 1923.

"Economic Value of Admixtures," by Pearson and Hitchcock; Proc. American Concrete Institute, 1924.

"New Test for Consistency of Paving Concrete," by Jackson and Werner; Proc. American Society for Testing Materials, 1925.

"New Experiences in Field Control," by J. G. Ahlers; Proc. American Concrete Institute, 1926.

"Seven Years' Experience with Job Control of the Quality of Concrete," by R. B. Young; Proc. American Concrete Institute, 1926.

"Concrete of Specified Strength," by O. Graf; Zeit. Vereines Deutscher Ingenieure, No. 12, p. 411, 1926.

Promoting That Stadium

The October issue will contain the first installment of an important article on the promotion, financing and design of athletic stadiums, with particular attention given to the requirements of such a project in the smaller city. The authoritative information to be presented in this series will be well worth the attention of the concretor who would like to promote such a venture for his home town. This timely article, coming in the midst of the football season, will be worth attention.

Aerocrete Demonstration
at the
Sesqui-Centennial Exposition

Interesting Facts About New Form of Lightweight Concrete — Manufacturing Methods — Tests — Variety and Examples of Uses

By J. GUSTAF V. LANG, E.E., M.E.

A NEW building material which has been developed and extensively exploited in Europe and other parts of the world is making its bow to the American public at the Sesqui-Centennial Exposition in Philadelphia. Aerocrete is a form of concrete of cellular structure produced by the addition of certain chemicals to the mass, which chemicals generate gases forcing the mass to rise in a manner similar to baker's dough. This cellular structure is responsible for the exceptional lightness, low heat conductivity and superior sound-proofness of the material.

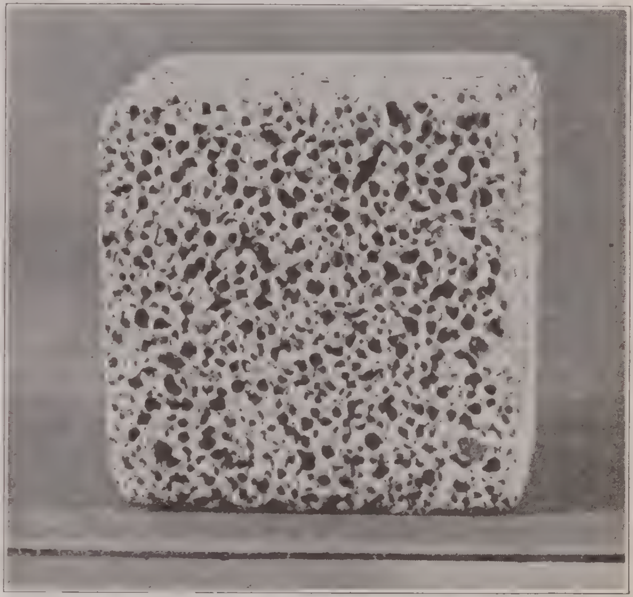
The qualities of this material can be varied within fairly wide limits, partly by varying the ratio of aggregate to cement and partly by varying the porosity. The common run of Aerocrete, however, weighs between 50 and 60 lbs. per cubic foot, and the corresponding strength runs from about 300 to 600 lbs. per square inch (by cube test). The coefficient of thermal conductivity varies from .15 to .19 B.t.u.

Aerocrete is fireproof, is far less absorbent than brick, ordinary concrete or any other materials for walls; it is rat and vermin proof, adheres to stucco and plaster with a far stronger bond than other materials, can easily be worked with ordinary wood working tools, viz., sawed, grooved, spiked and screwed, and does not require any special precautions against condensation in the way of furring, etc.

Aerocrete can be made into slabs, blocks, lintels, window sills, stair steps and practically any other forms required. Any desired surface can be provided in the form simultaneously with the molding of the products.

Used Monolithically

Aerocrete can also be used on the building site, the same as ordinary concrete, in vertical forms, or, due to its lightness it is possible to pour curtain walls in large sections in horizontal molds, subsequently raising the wall section into position. Several factories have been built in this manner in England and whole cottages are being built in Palestine by this method. Even the two-story cottage which was erected at the Wembley Exposition in England was built by molding the complete walls in horizontal forms, with window frames, door frames, etc., all laid in position and molded in place.


A block of Aerocrete, approximately full size

The bungalow shown in the accompanying photographs, which has been erected at the Sesqui-Centennial Exposi-

Two views of the Aerocrete bungalow at the Sesqui-Centennial Exposition

tion, is built of Aerocrete blocks which were made on the spot.

The equipment for making Aerocrete blocks is exceedingly simple. An ordinary mixer and a wooden trough as a form will do. Of course, metal forms are preferable and are naturally employed when blocks and slabs are being made on a manufacturing basis.

A visit to the Aerocrete bungalow will undoubtedly be of great interest to the readers of CONCRETE. Mr. Erik Bjorkman, who is in charge of this exhibit, is provided with facilities for showing visitors the actual process of molding Aerocrete blocks.

There are also on view a great many examples of the use to which Aerocrete can be put. Visitors will see blocks molded in Aerocrete, reinforced roofing slabs, partitions, etc.; they will be shown blocks made with cinders as aggregate, as well as with fine sand; blocks with Haydite and others with broken bricks as coarse aggregate; blocks with all kinds of facings, stair steps, lintels, etc., and they can even see a concrete wash tub made in Aerocrete, surfaced in white cement impervious to water.

The adhesive quality of Aerocrete is demonstrated by an exhibit of several layers of brick held together by a thin Aerocrete mortar, put on with a brush. This exceptional adhesive quality of Aerocrete has been taken advantage of in England and other European countries in the surfacing of cement floors. It has been found that by the use of a brush coat of Aerocrete the final finishing coat can be reduced in thickness to only a fraction of the usual finishing coat.

Advantages

The outstanding features of Aerocrete are, however, that it does not cost more than ordinary concrete, it weighs only one-third as much and is four times as insulating against heat or cold. Its use in outside walls entirely eliminates condensation troubles which generally have been associated with outside walls of concrete and have formed the main obstacle to a more universal adoption of this material for outside wall construction.

For the benefit of those readers who will not have the opportunity to visit the Aerocrete bungalow at the Philadelphia Exposition, some of the exhibits have been especially photographed and reproduced herewith.

Coloration of Concrete: A New Process Explained

By G. N. White, D.Sc. (London), F. I. C.

The statement that dyes can be satisfactorily used for coloring concrete has aroused keen interest throughout the building industry. It is as yet too early to estimate how far-reaching may be the results of the new process, but already one may feel fairly confident of its success. It is based upon well-established scientific facts, and any failure will be due to reasons which, at the present time, cannot be explained or foreseen by chemical and physical knowledge.

The new process employs those organic dyestuffs which have the greatest fastness to light, moisture, and other atmospheric effects, and which in the finished state are completely insoluble in water. The color range of such dyestuffs available for use in the building trade is very extensive, and there seems to be no reason why concrete should not now be tinted to produce any reasonable color scheme desired by an architect.

The process is simple, and is equally applicable to the coloring of concrete for use in mass or as blocks. The concrete is gauged, not with water and the color in powder form, but with a solution of some simple derivation of the coloring matter. On exposure to the air or by other simple treatment, the coloring matter is thrown down in a permanent insoluble form upon the cement particles.

The difficulty in coloring concrete by means of pigment in powder form is to grind down the particles of pigment more finely than those of cement. If they are larger, the cement particles will cover them with a cement dust, and tend to produce a greyish effect. But the extreme fineness of cement makes it practically impossible to grind down any pigment into particles that are smaller than those of cement. If this could be done, a color effect might be obtained with the use of a much smaller quantity of pigment.

This, however, is really the basis of the new process. By working with a solution of a derivative color or—in rather less exact language—a solution of the color, one actually employs the pigment in the most perfect state of subdivision possible. Although, on precipitation, there is doubtless a sort of coagulation, the precipitation occurs on the surface of the cement particles. The result is that quite a satisfactory depth of shade can be produced by the use of no more than 0.1 per cent to 0.6 per cent of coloring matter, calculated on the dry weight of the concrete.

It is noteworthy that the depth of tint depends only on the ratio of dyestuff to cement; so long as this is constant, it is immaterial—as far as the color is concerned—to what extent sand or other aggregate is added. Thus, a 1:7 mixture of sand and cement containing 0.06 per cent of dye has practically the same depth of shade as pure cement containing 0.4 per cent of dye. This brings out very clearly the dependence of methods of coloring concrete upon the area of the particles to be colored, since the addition of, say, 86 parts of sand to 14 parts of cement increases the total particle area of the latter by only some 5 per cent.

In practice the method would merely consist in gauging the cement or concrete with a solution instead of with water; and the dyes most suitable for this work would be those that can be brought into solution in the gauging water by simple treatment with a small quantity of alkaline salts. As the gauging is in progress and the concrete is being turned over, oxidation back to the original insoluble dyestuffs takes place, and by the time the concrete is applied the whole mass is colored right through. In some cases the oxidation occurs with less rapidity, and the concrete may have to be applied before the original dyestuff is thrown down. This, however, presents no difficulty, as the oxidation will be complete before it has finally set.

Although the coloring matters used must of necessity be organic in constitution, this need not involve any fear as to the permanency of the color; in fact, there are reasons for believing that the organic colors will be more permanent than the general run of pigments. Although it is not possible to speak definitely until the new building material has been tried out for some years, it is reasonable to suppose that a color which is *on* the cement particles, instead of *between* them, will prove less liable to fade by erosion.

These organic colors also are inert to sulphuretted hydrogen, sulphur dioxide, or other components of the atmosphere of large towns, which might have a darkening or other effect upon mineral colors. This is a most important consideration to architects; for, despite excellent educational work against the evils of domestic smoke, few housing authorities have yet definitely adopted gas fires and other anti-smoke appliances even in their modern garden suburbs.

It is hoped that a trial on an extensive commercial scale will be shortly undertaken to show the advantages of the method, both for internal and external decoration. Any building scheme adopting it for the first time will be the center of more than usual interest.—*The Chemical Age.*

Northwest Products Men Meet at Pacific Beach

The newly organized Northwest Concrete Products Association is getting under way with vigor. Their first semi-annual meeting was held at Pacific Beach, Washington, on July 30-31, and was attended by representatives of 21 member companies.

The opening session was devoted to the usual address of welcome, reading the minutes of the previous meeting, and reports of the committees. The executive committee reported on the Concrete Products Association convention held in Chicago last February, and advised affiliation with the national organization and that all possible members obtain Certificates of Quality. This latter point was explained and the Wisconsin association and the national association were given as examples on how these certificates work to the benefit of the members holding them and to the entire industry.

The Legislative Committee reported growing sentiment in favor of products and outlined suggested activity along legislative lines. The committee on Standards and Investigation recommended several methods of obtaining better quality products, while the Brick Committee reported on the size, strength and absorption of concrete brick, and the Building Trim and Roofing Tile Committee presented specifications for trim used with success by the chairman of the committee in his plant. The Traffic Committee reported that application had been made for a 30 per cent reduction on the freight rate on concrete pipe. The Advertising Committee recommended that one-third of the dues collected should be used for advertising purposes and that standards should be adopted so that the advertising could be given a good talking point. The Plant Operations Committee reported on the need for study of yard handling of products.

During the course of the convention papers were read that were of a very beneficial nature. Prof. A. L. Miller, University of Washington, spoke on "The Effect of Hot Water Vapor on Setting of Portland Cement." George Gauntlett, president, Northwest Branch, Associated General Contractors, of Aberdeen, Washington, spoke on "The Irresponsible Contractor and the L. I. D. Laws of Washington and Oregon." Russell V. Mack, of the Aberdeen *World*, discussed advertising. H. M. Schulman, of the Anchor Machinery Company, gave an interesting talk on the products plants in the east. Gordon Tongue, of the Superior Portland Cement Co., Inc., read a paper on freight service. Lee Johnson, Tacoma contractor, spoke upon the subject of "The Contractor and the Products Manufacturer." Rev. T. H. Simpson, of Olympia, told "Why Some Business Men Are Unpopular." L. A. Perry, construction engineer, Long-Bell Lumber Company, spoke on the water-cement ratio control of concrete mixes. A. J. R. Curtis sent in a paper, read by the secretary, on fire insurance rates on concrete masonry. J. deForest Griffen, architect, of Chehalis, gave the architects' view of concrete products.

The balance of the session was given over to the discussion of organization matters, and talks on organization methods, certificates of quality, the establishment of a scholarship at the University of Washington, and similar matters. The association adopted motions and resolutions that will result in the expenditure of one-third of the dues be used for advertising, the establishment of the scholarship, fixing the dues at $15 a year, affiliation with the Concrete Products Association, and work for legislation that will restore L. I. D. bonds to a parity standing. The convention then adjourned without fixing the time or place for the next meeting. Arrangements for the second annual convention, will accordingly be made by the executive committee, and this affair will probably be held during the latter part of next January.

Heavy Duty Terrazzo Floors

(Concluded from page 44)

Under the above specifications the traprock finally furnished to the job by the producer conformed to the following sieve analyses:

GRADATION OF AGGREGATE

TRAPROCK 5 "A"
(One part used in mix)

Sieve size	Per cent retained
¼ inch	17.76
⅛ inch	48.02
1/14 inch	79.46
1/30 inch	95.11
1/50 inch	97.00
1/100 inch	97.80
Fineness modulus	4.35

TRAPROCK 5 "B"
(Three parts used in mix)

Sieve size	Per cent retained
½ inch	0.00
⅜ inch	12.43
¼ inch	46.64
⅛ inch	75.04
1/14 inch	88.13
1/30 inch	97.88
1/50 inch	99.33
1/100 inch	99.75
Fineness modulus	5.19
Per cent of voids in mixture	43%

The mix prepared with this gradation of aggregate was quite workable and eliminated the use of an excess amount of cement that would have been called for by the mix originally proposed. For the sake of convenience, since a number of small concrete mixers were used on the job, the mix was changed from 1:2 to 1:1.7, in order that a batch could be made up with three sacks of cement and five cubic feet of stone. The carborundum grit filler was changed from the 1:2 mixture used in the experiments to a 1:1 mixture. The weight of the finished topping provided by the method adopted was found to be 7½ pounds per square foot when the topping was laid ¾ of an inch thick.

The lower floor topping on the job was laid one inch thick, with an area of 110,000 square feet, and the second and third floor topping, each comprising an equal area, was laid ¾ of an inch thick.

It was thus, by the methods described in this story, that the material dealer, the contractor, the engineer, and the owner cooperated in a simple but effective series of tests that determined the specifications required to enable the laying of a terrazzo floor that would give long years of service under exceptionally heavy traffic.

In Our October Issue

Mr. Lindau will review the history of reinforcing.

Mr. Brett will reveal French bridge building secrets.

More about building codes. The new British cement specifications, concrete poles in Sweden, concrete stadiums, portland cement clinker, Fire-Prevention Week, winter work and other interesting topics will be given attention.

New Equipment

Up- or Down-Face Machine Produces Square Foot of Tile in Each Operation

A machine has recently been put on the market that is claimed to produce one square foot of tile per operation, 10/1000 of an inch true to measurement, either up or downface, using a slurry mix or trowelling in the color or finish. Mold boxes and pallets are furnished in sizes from 2 to 12 square inches.

The machine is built entirely of steel, and the mold box is machined down to perfect face, all cross joints in the latter being mortised and bolted together. Under the mold box is a square plate, the full size of the machine through which a series of holes are bored and threaded, to hold the square block on which the pallet rests, the whole being forced up through the mold box when the tile are finished.

The thickness is secured with a long set screw, backed up for heavy tile and tightened for thin tile, the thickness being variable from ¼ inch to 3 inches.

A. C. Dale, Columbus, Ohio, is the inventor and manufacturer.

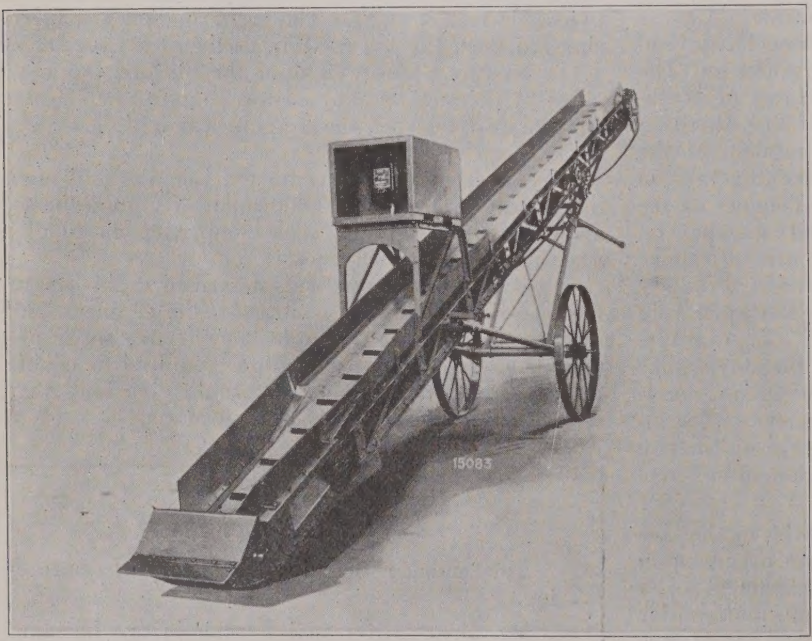
New Admixture Introduced to Eastern States

Another innovation has come out of the west. A new admixture that lubricates the mix and adds waterproofness, rapid curing, strength and density, has been introduced to the states east of the Rockies after several years of use on the west coast. This material, known as Kallite, is a diatomaceous earth product that has desirable properties, and is recommended for use in monolithic concrete, concrete block, brick and tile, garden furniture, portland cement stucco, and other kinds of concrete work.

Mixtures in which Kallite is used can be chuted or placed in a comparatively dry state, says the manufacturers, without danger of free water or segregation. A laboratory report indicates a marked increase in strength when the admixture is used in the proper proportions. Since the function of the material is that of a lubricant, the mix requires less water, thus avoiding segregation, loss of strength, and the free water that frequently gives trouble in making concrete products.

Three per cent is used in a 1:2:4 mix, and greater quantities in the leaner mixes. Five pounds of the material per sack of cement is recommended for use with stucco. An additional 1 per cent is ordinarily specified when a waterproof job is desired. The material is supplied in 100-pound cloth sacks, and is warehoused in Chicago. This new material may be secured from the Tamms Silica Company, 30 North LaSalle Street, Chicago, Ill.

Improved Type of Portable Conveyor



The *Jeffrey Manufacturing Company* of Columbus, Ohio, has recently put on the market an improved type of portable belt conveyor for handling sand, gravel, crushed stone, brick and tile. The following several new developments are incorporated in the apparatus: Steel side boards bent to extend under the side of the belt forming with the belt a moving trough, an improved type of carrying idler to support the loaded portion of the belt and an extended and flared loading leg at the bottom, edged with belting material to form a seal with the moving belt.

New Joint System Controls Cracks in Concrete Roads

A system of longitudinal and transverse joints that, when installed in the concrete pavement, will control cracking, has recently been announced by the Flexible Road Joint Machine Co., Warren, Ohio. Known as the Flex-Plane system, it consists of a corrugated parting strip in the bottom of the slab reaching to the dowel, and removable steel joint plates that leave a deep notch through the upper part of the slab, which is filled with a suitable joint filler. An expanding cover bar is used in connection with the joint plate, and these two are removed after belting is completed.

Improved Wheelbarrows

An achievement in wheelbarrows, including interchangeability of trays and four guaranteed measuring capacities is noted in the literature of the *Akron Barrow Company*, Cleveland, Ohio.

Wear on the front of the tray has been reduced by a curve in the braces, while higher backs and sides have been designed for less spilling and better dumping.

Siphon Water System for Pavers

Measurement of water with as great accuracy as is obtained by weighing apparatus is said to be secured by the new pressure water system designed by the *Chain Belt Co.*, Milwaukee, Wisconsin, for its 27-E paver. In addition, the water is gotten into the drum in about ten seconds with practically no dribble.

The water system consists essentially of a 42-gal. drum type tank from which the quantity of water delivered is controlled by a siphon at one end, which can be rotated about the axis of the tank. When the mouth of the siphon is uncovered and the air breaks the siphonic action, the shape of the siphon is such that all of the water above its mouth is discharged and the flow stops almost immediately.

Mixer Musings

Reported by "Joe"—The Mixer Boss.

An' They Called It Concrete

Not so long ago my old boss got caught in a jam an' phoned for me to come over and see what had happened. He'd decided that it was cheaper to sub-let the concrete work where only footin's were concerned than to put his concrete gang on the job, and so he'd sub-let the footin's on this job to a feller who was pretty anxious to get a job anyhow. Then the steel gang got busy and busted up the footin's in many places trying to get the columns set, and so the job was tied up tighter'n blazes while the architect decided what to do about it.

When I slid down the ladder an' into the hole it didn't take no fortune teller to see that the job was jinxed—an' jinxed right. Here was a mess of footin's an' a retainin' wall that looked like a ton of TNT had gone on a spree in the neighborhood of. Chunks the size of my fist had falled off wherever somebody had rammed somethin' up against the stuff, and the places where the columns were supposed to sit looked like a relic of the war. Then there were good-sized cracks running up an' down the wall in places, and there were other spots that looked like nothin' but loose stone. It was plain to see that the whole works would have to be removed an' done all over again.

The sub-contractor was still on the job, waitin' for a chance to begin the fireproofin' an' he was just then doin' some odd jobs around there to keep his men busy. So I went around to the mixer, and the cat was out of the bag for sure! Here the durn idiot of a mixer boss was just shakin' a cement sack at the batch an' then goin' to sleep on the water faucet, with the result that the stuff was like a lumpy soup with just enough cement to cloud the water a bit. His aggregates were measured by eye as they escaped down the chute to the mixer, and a lazy nigger had charge of the few cement sacks on the platform. The water came in from a battered tank that nobody had remembered to set for any particular water content. Then the mixer was given a scant three-quarters of a minute to do its work, an' they called it concrete.

It's no wonder that the old man has sworn off sublettin' his concrete work and is now startin' to do it all himself so as it would be done once only for each job, an' not twice, while the other trades had to wait in line.

The fellow who said the man on the job need not know anything about neutral axis, the design of columns, or about moments, was all wrong. You won't catch the average man putting the steel in the wrong place once he knows what it is in there for besides to use up the material. He won't leave out the stirrups, either, like one man we have heard about. Make every man an "engineer" and then watch the difference.

Why don't more of you fellows drop me a line? There ought to be a lot of yarns we can swap, if you'd only agree to get together with me, if only by mail. What have YOU seen or heard that would hand ME or the other fellow a laugh, or at least a good chuckle? Yours till the cylinder busts,

Joe, The Mixer Boss.

News of the Industry

With the Manufacturers

The Abram Cement Tool Company, formerly at 3818-3834 Grand River Avenue, Detroit, Michigan, has moved into its new home at 2300 Michigan Avenue, at 15th Street, opposite the new Michigan Central passenger station, Detroit. The main office, salesroom, warehouse and factory are now located under the same roof.

The actual moving of the stock occupied more than ten days, a healthy comparison with the removal of the firm in its first year, in 1916, when a Ford truck carried the entire stock and fixtures to a new location in two hours.

The Abram Company occupies the three floors of the building, which has a display frontage on Michigan Avenue of 82 feet and 60 feet on 15th Street. A large electric freight elevator of sufficient capacity to accommodate loaded trucks facilitates the handling of all freight, and ample yardage on the property provides for expansion of the used equipment and rental departments. It is planned to extend the present lines to include builders' hardware and other lines of tools useful to the building and contracting trades.

C. J. Ullrich, member of the firm of McGonagle & Ullrich, consulting engineers, Salt Lake City, Utah, has been elected president of the *American Association of Engineers*. Mr. Ullrich began his engineering work with the Leonard Construction Company, Chicago. Since then he has been employed as resident engineer on the construction of the Idaho Falls Municipal Hydro-Electric plant and pumping station, on the Snake River; has been office engineer for the Utah State Road Commission, Deputy State Engineer of Utah, and, since 1921, a member of the present engineering firm. Mr. Ullrich is also an attorney-at-law and confines his legal practice entirely to engineering matters.

The Asbestos Shingle, Slate and Sheathing Company of Ambler, Penn., has purchased 15 acres of land at St. Louis, Mo., as a site for a western factory for making its asbestos shingles, corrugated roofing, asbestos lumber and other asbestos products. The tract is located on the city line to the north of St. Louis. It extends along the Chicago, Burlington and Quincy Railroad and is adjacent to a large cement plant that will supply the large quantities of cement used in the manufacture of the company's products. Building operations are to be started at once.

A western office for the *Hydraulic Stone Machinery Company* has been opened at 7 West Grand Avenue, Chicago, Ill. Mr. Charles L. Jones, who is general manager of the company, will be in charge.

The Hydraulic Stone Machinery Company has recently been incorporated and are taking over the interests of W. H. Fisher and the Hydraulic Ramming Concrete Stone Machinery Company. The officers of the new company are: W. H. Fisher, president and treasurer; John W. Hayes, vice president; Howard F. Bresee, secretary; L. Karlton Mosteller, attorney, and Charles L. Jones, general manager.

The Heil Company, Milwaukee, has opened a factory branch office and service station for the New England territory at 298 North Harvard Street, Boston (Brighton), Mass. *Clarence H. Zarse*, formerly of the general sales staff, is the branch manager.

This branch is adequately equipped to expedite the mounting of Heil products.

Arthur Nicolaus has been named advertising manager of the *Heil Company, Milwaukee*, the position recently vacated by Howard Winton. Mr. Winton is now in charge of the promotion and activities of *Heil Company* branches and distributors as general branch manager.

C. D. Hale, a member of the engineering staff of the Structural Bureau, at the general office of the Portland Cement Association, Chicago, died on July 24, 1926, after a lingering illness brought on by a combined attack of influenza and pneumonia. Mr. Hale was a graduate in civil engineering from Northwestern University, Evanston, Illinois. He served in France during the World War, as first lieutenant in the artillery and motor transport corps, and lately held a commission as captain in the 65th Division, cavalry reserve corps. He is survived by his wife and baby daughter. He was buried at Princeville, Ill.

Industrial Literature

Opportunities in the Manufacture of Concrete Products is an interesting booklet recently issued by the *Besser Sales Company*, 53 West Jackson Blvd., Chicago. These manufacturers of products plant machinery have prepared this booklet, an example of good printing, with the idea of showing the prospective products manufacturer the basis and fundamental importance of the products industry. Statistics and facts are quoted that would interest the real business man to invest his money in the growing industry. The booklet not only sells the market, but sells the material as well. The booklet tells briefly about the engineering service rendered by the company and the success of plants using Besser machines. Even though fully equipped, the present products manufacturer should read this booklet for the inspiration that it will give him.

The Medusa Concrete Products Book, just off the press, is an unusually good example of how a cement manufacturer can appeal to the architect and to the concrete products manufacturer by means of a special booklet. *The Sandusky Cement Company*, of Cleveland, has done well to cover the production of high grade products in such an interesting and informative way, and to dress up the information as well as has been done with this latest booklet. Concrete block, tile, brick, trim stone, floor tile, roofing tile, ornamental products, burial vaults, monuments and markers, mortar, colors for products, mixing concrete for products, curing, crazing and map checks, fence posts and silos all have their place in this volume.

Concrete Masonry Construction, a new manual for the architect and the contractor, has just been covered in a new booklet issued by the *Portland Cement Association*, Chicago. This interesting and valuable text is replete with information and drawings and photographs enabling the builder to obtain full advantage of the properties of concrete masonry units. The chapters of the booklet cover such subjects as the characteristics of concrete masonry, concrete masonry construction, concrete floors, concrete masonry as a base for stucco, fire-resistive roof coverings, construction details, specifications, a recommended ordinance for concrete block and tile, a typical calculation for wall footings, and notes on construction of concrete residence floors.

A manual of concrete hardeners containing detailed architectural specifications for colored and uncolored hardeners, both integral and surface treatments, has been compiled by the *Master Builders Company* and published for architects, engineers, builders and building owners. This is a complete manual of concrete hardener specifications with illustrated descriptive matter arranged systematically, with specifications so worded that they can be incorporated in a general paragraph or in detail into building specifications.

A second book of the same size covering waterproofings has the same unique arrangement of contents. Both books are supplied upon request by the *Master Builders Company*, Cleveland, Ohio.

Bar benders in different sizes for various uses are described in the catalog newly issued by *Kardong Bros., Incorporated*, Minneapolis, Minnesota. Included also in this publication are the descriptions and capacities of other reinforcing fabrication devices, spacer punches, wire shears, wire straighteners, and column clamps. The manipulation of the latter is especially simple, the adjustment of each clamp averaging about a minute.

Washington, D. C.—The Department of Agriculture has just issued a bulletin, *Small Concrete Construction on the Farm*, demonstrating the feasibility of construction by the farmer himself of many useful structures. The bulletin describes how to build sidewalks, feeding floors, basement and barn floors and similar pavements. The method of building tanks for watering stock and storage of water is outlined and tables are given to show the amount of reinforcement required for square and round tanks, of such sizes as are readily built by one unskilled in the use of concrete. Hog wallows, manure pits, dipping vats, milk cooling tanks and a concrete water heater are illustrated and instructions given for construction. The bulletin gives a great deal of information relative to the use of concrete on the farm distinctly favorable to this type of construction.

A Preliminary Experiment on the Supporting Strength of Culvert Pipes in an Actual Embankment, by M. G. Spangler, is the title of Bulletin 76 of the *Engineering Experiment Station, Iowa State College*, Ames, Iowa. The bulletin records the results of an investigation carried on at Ames, Iowa, by the experiment station in cooperation with the United States Bureau of Public Roads. In this experiment, 10 sections of practically unreinforced concrete culvert pipe, 36 inches in diameter, 23.5 inches long, and with 3-inch shell thickness, were tested under embankment loads. The experiments roughly confirmed Rankine's formula.

Catalogue of Industrial Books, published by the Norman W. Henley Publishing Co., 2 West 45th Street, New York City. This is a complete catalogue of the practical, scientific, mechanical and industrial books published and carried in stock by that concern. The new edition of that catalogue contains a number of books on concrete work and should prove of interest. Copies will be sent gratis to any one requesting them.

Organizations

American Concrete Institute; Harvey Whipple, Secretary, 2970 West Grand Blvd., Detroit.

American Concrete Pipe Association; M. W. Loving, Secretary, 33 W. Grand Ave., Chicago.

American Construction Council; Dwight L. Hoopingarner, Executive, 28 W. 44th St., New York City.

American Engineering Standards Committee; Dr. P. G. Agnew, Secretary, 29 West Thirty-ninth St., New York City.

American Road Builders' Association; Wm. H. Connell, President, Miss E. A. Birchland, Secretary, 29 W. 39th St., New York City.

American Society for Testing Materials, C. L. Warwick, Secretary-Treasurer, Engineers' Club Building, 1315 Spruce St., Philadelphia, Pa.

Associated General Contractors of America; D. H. Sawyer Secretary, 1038 Munsey Bldg., Washington, D. C.

Associated Metal Lath Manufacturers; 123 West Madison St., Chicago; Wharton Clay, Commissioner.

Building Officials Conference: H. E. Plummer, President, J. F. Downey, City Hall, Cambridge, Mass., Secretary.

Concrete Reinforcing Steel Institute; M. A. Beeman, Secretary, Tribune Tower, Chicago.

Concrete Products Association; John E. Powers, President, Sterling, Ill.; D. R. Collins, Secretary, 47th and State Streets Alois postoffice, Milwaukee, Wis.

Iowa Concrete Products Association; H. E. Meier, President; R. L. Gavin, Secretary-Treasurer, 405 Hubbell Bldg., Des Moines, Iowa.

National Association of Building Trades Employers; A. E. Coleman, President, 37th St. & Stewart Ave., Chicago. A. W. Dickson, Executive Secretary, 214 Electric Bldg., Cleveland, Ohio.

National Association of Builders' Exchanges; William F. Chew, Baltimore, President; Earl F. Stokes, Secretary, 15 East Fayette St., Baltimore, Md.

National Crushed Stone Association; J. R. Boyd, Secretary, 751 Earle Building, Washington, D. C.

National Housing Association; Lawrence Veiller, Secretary and Director, 105 East Twenty-second St., New York City.

The National Lime Association; Burton A. Ford, Secretary, 918 G Street, N. W., Washington, D. C.

National Slag Association; H. J. Love, Secretary-Treasurer, 933 Leader-News Building, Cleveland, Ohio.

National Sand and Gravel Association, V. P. Ahearn, Executive Secretary, 1045 Munsey Bldg., Washington, D. C.

Ohio Concrete Products Association; G. M. Friel, Secretary-Treasurer, 2284 North High St., Columbus, Ohio.

Portland Cement Association; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

Wisconsin Concrete Products Association; A. P. Kuranz. Secretary-Treasurer, 425 E. Water St., Milwaukee.